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MECHANICAL ENGINEERING

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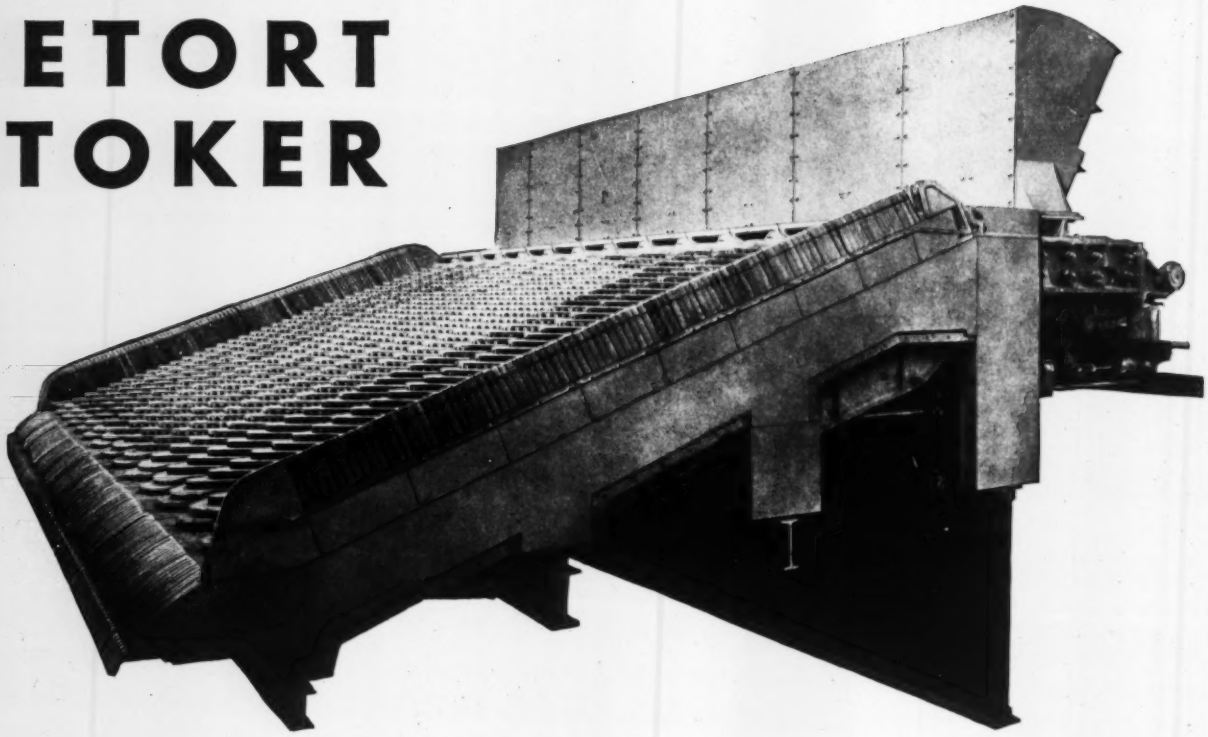

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Contributors to This Issue

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J. E. Hannum, editor of the A.S.M.E. Engineering Index since 1927, was educated at Pennsylvania State College, from which he received the degrees of B.S. and M.E. After graduation he was connected with the Skinner Engine Co., Erie, Pa., as machine-shop foreman, and later became an instructor in industrial management at Purdue University. His next position was with the Diamond Chain & Manufacturing Co. as efficiency engineer, from which he resigned to take charge of the industrial education of blinded soldiers at the Red Cross Institute for the Blind, Baltimore, Md.

C. B. Fritsche, president, Aircraft Development Corporation (Lighter-than-Air Division) and of the Detroit Aircraft Corporation, practiced civil and mining engineering until the outbreak of the World War, when he became interested in aeronautics although not actively engaged in the Air Service. In 1921 he initiated a preliminary investigation of the possibilities of all-metal construction of rigid metal airships. The next year he organized, with others, the Aircraft Development Corporation, and since that time has been engaged in lighter-than-air development exclusively, resulting in the construction and successful demonstration of the "ZMC-2" metalclad airship for the U. S. Navy. In 1925 he organized with others the National Air Transport, Inc., the first commercial air-mail transport line in the U. S., and served as secretary of this company from 1925 to 1927.

C. T. Porter, vice-president and chief engineer of the Keystone Aircraft Corporation, was graduated from Yale University in 1907. After a short apprenticeship with the Westinghouse works in East Pittsburgh, he went to China as professor of civil engineering in the Imperial College at Shanghai. In 1910 he returned for a year's graduate work at Columbia University, then becoming an instructor of applied mechanics at Yale. In 1918 he resigned to become associated with the Naval Aircraft Factory in Philadelphia, as aeronautical engineer. Two years later, with others, he organized the Huff-Daland Co. for the building of airplanes, with the plant located at Ogdensburg, N. Y. In 1925 the plant was moved to Bristol, Pa., and the name changed to the Keystone Aircraft Corporation.

M. F. Sayre, associate professor of applied mechanics at Union College, received the degree of E.M. from Columbia University in 1907 and A.M. in 1911. From 1907 to 1910 he was engaged in mining and railroad work in Arizona, then accepting the position of assistant to William H. Burr at Columbia. From 1911 to 1913 he served as superintendent of construction of the Croton Magnetic Iron Mines in Brewster, N. Y.; the following year he spent with the New Jersey Central Railroad. Since 1914 he has been associated with Union College.

Geo. A. Orrok, consulting engineer, New York, N. Y., was graduated from the Massachusetts Institute of Technology in 1888. From 1891 to 1898 he was associated with the late Dr. F. S. Pearson, engineer, and from then until 1916 with the New York Edison Co.

H. N. Davis, president of Stevens Institute of Technology, received his degree of A.B. from Brown University in 1901 and his A.M. the following year. He also holds the degrees of A.M. and Ph.D. from Harvard University, where from 1905 to 1927 he served on the faculty as an instructor in physics, assistant professor, and professor of mechanical engineering. He was associated with the United States Bureau of Mines in a consulting capacity from 1921 to 1925, and also with the Franklin Railway Supply Co., 1920–1927, and the Air Reduction Co, 1922–1925. Dr. Davis was called to assume the presidency of Stevens in 1928, and was formally inaugurated on November 23 of that year.

J. H. Keenan was graduated in 1922 from the course in naval architecture and marine engineering at the Massachusetts Institute of Technology, and then entered the employ of the General Electric Co., Schenectady, N. Y., where he carried on research and development work relating particularly to steam flow. Since September, 1928, Mr. Keenan has been on the faculty of Stevens Institute as assistant professor of mechanical engineering.

S. T. Powell is a consulting chemical engineer and associate in engineering at Johns Hopkins University. His chemical training was received at Rensselaer Polytechnic Institute, and he has specialized in the purification of water for sanitary and industrial uses and the treatment of sewage and trade wastes. He is consulting engineer to a number of public-utility groups.

This month's cover is a picture of the partly completed Goodyear-Zeppelin Corporation airship factory and dock now under construction at Akron, Ohio. This structure covers eight and one-half acres of floor space and in it will be constructed the "ZRS-4" and "ZRS-5" for the United States Navy. The picture is of particular interest in connection with Mr. Fritsche's paper in this issue on "The Metalclad Airship."

MECHANICAL ENGINEERING

Volume 51 December, 1929 No. 12

Engineers in American Life

By L. W. WALLACE,[1] WASHINGTON, D. C., AND J. E. HANNUM,[2] NEW YORK, N. Y.

DR. ARTHUR T. HADLEY, in an address at the dedicatory exercises of the Engineering Societies Building in New York in 1907, said: "Let a man or group of men arise who add to their technical knowledge a readiness to use that knowledge in the public service, and people will be ready to put them in charge of affairs and follow where they lead. . . . . We celebrate today . . . . the recognition of science as a necessary guide in the conduct of the material affairs of each man's business. Half a century hence, when our descendants shall meet . . . . I am confident that they will celebrate a yet greater thing . . . . the recognition of the right of men of science to take the lead in enlightening the thought of the people in public affairs and the responsibility of filling the highest positions in the service of the commonwealth."

In his book entitled "Mathematical Philosophy," Dr. Keyser of Columbia discussed the engineering profession seriously, appreciatively, but critically. He defined engineering as "the science and art of directing the civilizing energies of the world to the advancement of the welfare of man." Said he, "that conception does not represent engineering as it has been practiced in the past nor as it is practiced today. It represents an ideal which engineering will approximate more and more just in proportion as it becomes more and more humanized and enlightened. This ideal is an inspiring one; but it ought not to flatter the vanity of professional engineers; it ought rather to give them a feeling of humility.

"In view of these considerations it is easy to see . . . . that the characteristic marks of the great engineer will be four: Magnanimity, scientific intelligence, humanity, action.

"He will be religious and he will be patriotic; 'to do good' will be his religion, and his love of country will embrace the world. For he will be the scientific organizer and director of the civilizing energies of the world in the interest of all mankind."

Of the 28,805 "notable living men and women of the United States" named in "Who's Who in America" (1928-1929), men of science comprise 30.4 per cent; lawyers, 15.2 per cent; and physicians and surgeons, 7.3 per cent.

The 2858 engineers and architects named received 1417 academic degrees in branches of learning other than science, as well as 2497 scientific degrees.

These 2858 engineers and architects are members of 1138 associations, conferences, boards, and commissions, half of which are non-technical.

They hold 4785 official positions in 3928 organizations, of which number 2993 are industrial and commercial companies.

They occupy the position of president in 1128 industrial and commercial organizations, 72 engineering firms, 68 banks and trust companies, and 23 colleges and universities.

Among these 2858 engineers and architects there are, or have been, 10 governors, 13 members of Congress, 2 members of the Cabinet, and the President of the United States.

The findings of this assay clearly show that engineers and architects are versatile, not narrow; internationally, not provincially minded; leaders, not followers; scholarly, not unlearned; cultured, not rude; humane, not cruel; lovers, not haters of mankind.

These statements concerning engineers and engineering are thought provoking, the more so because expressed by two eminent men without the profession. They envisage the engineer as a hope—a promise—an agent to remove the impediments to human progress and happiness throughout the world.

Contrast, if you please, the foregoing inspiring but sobering evaluation of the engineer with the statement made by Philip Schuyler, himself an engineer, in a recent address at the University of Southern California, in which he said: "We have overspecialized engineers, diligent, practical, serious, and technically efficient it is true . . . . but otherwise uncultured, and thus handicapped in the economic struggle of today."

Perhaps we should not take this unwarranted indictment of the engineer seriously were it not for the fact that Mr. Schuyler has merely expressed in his own words a thought frequently voiced by other engineers. Too often do engineers give expression to like thought.

Herbert Spencer, the great engineer and philosopher, in his essay on education, had no such idea when he said: "What knowledge is of most worth? The uniform reply is science. This is the verdict on all counts. For direct self-preservation, or the maintenance of life and health, the all-important knowledge is science. For that indirect self-preservation which we call gaining a livelihood, the knowledge of greatest value is science. For the discharge of parental functions, the proper guidance is to be found only in science. For the interpretation of national life, past and present, without which the citizen cannot rightly regulate his conduct, the indispensable key is science. Alike for the most perfect production and present enjoyment of art in all its forms, the needful preparation is still science. And for purposes of discipline—intellectual, moral, religious—the most efficient study is, once more, science."

A person of an inquiring mind is stirred to action by expressions of the nature quoted relating to his profession. He has a desire to determine who is correct, the one who commends or the one who criticizes. Being of an inquiring mind, we have made an effort to determine whether the engineers of America justify the hope and promise placed in them by Drs. Hadley and

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For presentation at the Annual Meeting, New York, December 2 to 6, 1929, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Keyser, or are uncultured, uninterested, and inactive with respect to the great problems of mankind.

In an engineering fashion we have made an assay of the engineering profession, using as a sample the engineers listed in "Who's Who in America" (1928–1929). We are aware that some will say it is an unfair sample; that it came from the best mine. This is readily admitted, with this qualification: that all engineers and architects by virtue of their training and experience have been freed of most of the dross to which mankind is heir. They are a selected group to begin with, having all the potentialities those in the sample possess. They will achieve, and many have achieved, although not included in the sample. Then again, neither Dr. Hadley nor Dr. Keyser pictured an arrival. They visualized a journey in process. Does the analysis of the sample disclose such a promising journey? is the answer we sought.

We are also aware that some will say a part of those included in the sample are not engineers. Our answer to that criticism is this: An engineer is no less an engineer because for the time being he is president of a bank, a university, an opera company, or a hotel company. Moreover, he is no less an engineer because he is a governor of a commonwealth, a United States senator, a member of the Cabinet, or the President of the United States.

Members of the engineering profession very frequently complain that engineers are not given proper recognition by the public, and then, just as soon as an engineer steps out of the bounds of engineering to the slightest degree, they disown him. No wonder many engineers become lost to the profession. Who lingers where he is not wanted?

The sample was taken from "Who's Who in America," because we knew of no more authentic and generally accepted list of prominent American men and women. Those whose accomplishments have warranted their being recorded therein are accepted by the public as being among the outstanding citizens of the nation. Using this accepted list frees us from the possible accusation of partiality or of giving undue weight to engineers and architects.

"Who's Who in America" (1928–1929) contains the biographies of 28,805 of the "notable living men and women of the United States." A determination has been made as to the number of those who are lawyers, physicians, surgeons, scientists, engineers, and architects. The members of each group were selected in accordance with the following specifications:

1 *Lawyers:*

- *a* Those listed as lawyers or judges.
- *b* Those who have received an earned academic degree of any grade in law and regardless of whether they have or have not been admitted to the bar or have practiced law.
- *c* Those who have been admitted to the bar regardless of whether they have or have not received an earned academic degree in law or have practiced law.
- *d* All those listed as members of the American Bar Association not otherwise included.

Persons with honorary degrees in law were not counted as lawyers if they did not, in addition, qualify under one or more of the above specifications.

2 *Physicians and Surgeons:*

- *a* Those listed as physicians, surgeons, or other medical specialists.
- *b* Those who have received either the academic, or honorary degree of Doctor of Medicine, Doctor of Veterinary Medicine, or Doctor of Dental Surgery, regardless of whether they have or have not practiced medicine or surgery.
- *c* Those who have practiced medicine or surgery or who have been engaged in medical work, regardless of whether they have or have not received a medical degree.
- *d* All those listed as members of the American Medical Association, not otherwise included.

3 *Scientists*—Excluding engineers, architects, physicians, and surgeons:

- *a* Those listed as scientists or specialists in the several branches of science. The selection was limited to those who deal largely with pure science or with some application thereof; that is, to those who use the scientific method in a strict sense.
- *b* Those who have received an academic degree in science regardless of whether they have or have not engaged in scientific work.
- *c* Those engaged in scientific work regardless of whether they have or have not received a scientific degree.

Persons with honorary degrees in science were not counted as scientists if they did not, in addition, qualify under one or more of the above specifications.

4 *Engineers and Architects*—The specifications were applied rigidly rather than liberally:

- *a* Those listed as engineers or architects.
- *b* Those who have received an academic or honorary degree in engineering or architecture.
- *c* Those who at some time have engaged in engineering or architectural work for at least two years.
- *d* Those who are members of national engineering or architectural societies having high membership requirements.
- *e* Industrial chemists whose major work has been chemical engineering.
- *f* Geologists engaged in mining or petroleum operations.

Persons were not counted who had no other engineering or architectural qualifications than membership in local engineering and architectural clubs. Likewise those were not counted who had studied but not completed an engineering or architectural course or had not engaged in engineering or architectural work, or who were not members of a national engineering or architectural society.

NUMBER IN EACH GROUP

The results obtained by applying the aforesaid specifications appear in Table 1. The total number is 15,227, or 52.8 per cent of those listed in "Who's Who." The scientific group represents 30.4 per cent of the total number.

TABLE 1 PROFESSIONAL MEN LISTED IN "WHO'S WHO"

Name of groups	Number	Per cent
Total number of biographies	28,805	100.0
Scientists (including engineers, architects, physicians, and surgeons)	8,763	30.4
Lawyers	4,379	15.2
Engineers and architects	2,858	9.9
Physicians and surgeons (including 57 dentists and 33 veterinarians)	* 2,116	7.3
Honorary Doctors of Laws (excluding lawyers)	2,065	7.2
Honorary Doctors of Science (excluding scientists)	20	*a*

a Less than 0.1 per cent.

In considering the data in Table 1, it should be remembered that the legal and medical professions are homogeneous. A lawyer is generally considered a member of the legal profession regardless of the particular type of legal or other work in which he engages. Likewise the doctor is considered a member of the medical profession without regard to the character of his work.

With respect to pure and applied science no such uniform thought prevails. Generally speaking, each of the several branches of science is considered by the public and in some mea-

sure by scientists themselves as a separate and distinct profession. This is also partially true of the several branches of engineering. Therefore the general public and men of science visualize several professions as existing in the realm of pure and applied science. This within itself is of no particular moment in most instances. However, when comparisons are made with respect to the influence of the several professions it makes a great deal of difference whether the men of all branches of science are considered as members of one profession or of many professions.

In comparing the relative activities of the several professions, all men engaged in pure and applied science should be considered as members of one profession as all lawyers and all doctors are considered as belonging to the legal and medical professions, respectively. Since this is the practice the thought prevails that lawyers and doctors are more prominent in American life than are men of science. This erroneous thinking is partly responsible for the inferiority complex so often apparent among the latter.

The men of pure and applied science comprise 30.4 per cent of the 28,805 men and women listed in "Who's Who." Of the total number, 9.9 per cent are engineers and architects. Lawyers account for 15.2 per cent of those listed, or one-half the number of men of science and only 5.3 per cent more than the number of engineers and architects. Physicians and surgeons are fourth, with a percentage of 7.3. The latter are outranked by engineers and architects by 2.6 per cent.

Analysis shows that the honorary degree of Doctor of Laws has been liberally conferred upon men who are not members of the legal profession, whereas the honorary degree of Doctor of Science has been confined almost exclusively to men of science. Only twenty persons have received the degree of Doctor of Science who were not classified as scientists, whereas 2065 persons who were not lawyers have been given the degree of Doctor of Laws.

ENGINEERS AND ARCHITECTS

The primary purpose of this paper is to determine to what degree engineers and architects are prominent in American life as shown by the training, experience, and activities of those listed in "Who's Who." Consequently a rather detailed analysis of the biographies of the 2858 listed has been made and will be presented in the following pages. The major grouping of these men appears in Table 2. The percentages total more than 100 per cent because the activities of many made it necessary to assign them to more than one group. In other words, these men are versatile; they do not confine themselves to a small or narrow area of activity.

The four major groups in order of percentage of the total number are: Mechanical, 21.2 per cent; Civil, 20.2 per cent; Mining and Metallurgical, 19.0 per cent; Electrical, 16.0 per cent.

TABLE 2 CLASSIFICATION OF ENGINEERS AND ARCHITECTS

	Number	Per cent
Total number of engineers and architects	2,858	...
Unclassified	5	...
Classified	2,853	100.0
Agricultural	21	0.7
Architectural (including architects)	305	10.7
Chemical	154	5.4
Civil	576	20.2
Electrical	455	16.0
Mechanical	603	21.2
Military (including Army and Navy officers and civilian engineers who have served in the Army and Navy	306	10.7
Mining and metallurgical	543	19.0
Railroad	166	5.8

EDUCATION

In "Who's Who in America" (1928–1929) is a table summarizing the educational background of all those named in the 1922–1923 edition. Although there is a gap of six years, the relative percentages have changed so little during a period of twenty-five years they may be used for comparative purposes.

Table 3 compares the extent of the education of the engineers and architects appearing in the 1929 edition with that of all persons listed in the 1923 edition.

The proportion of college graduates among the engineers and architects is 79.4 per cent and among all others 63.67 per cent, whereas in the first group 86.5 per cent attended college and in the second group, 77.36 per cent.

TABLE 3 EDUCATION

	Engineers and architects, 1929 edition		All persons in 1922–23 edition	
	Number	Per cent	Number	Per cent
Number furnishing sufficient educational information	2,829	100.0	22,075	100.00
Graduates of universities and colleges.	2,137	75.5	13,511	61.20
Graduates of the U. S. Military Academy	59	2.1	289	1.31
Graduates of the U. S. Naval Academy	49	1.7	255	1.16
College graduates (including Army and Navy)	2,245	79.4	14,055	63.67
Attended universities and colleges but did not graduate	191	6.8	2,988	....
Total number that attended college	2,436	86.5	17,077	77.36
Educated in academies, seminaries, private, and other secondary schools	161	5.7	1,574	7.13
Educated in high schools	87	3.1	1,182	5.35
Educated in common or public schools.	133	4.7	1,880	8.52
Self-educated	12	0.4	....	....

ACADEMIC AND HONORARY DEGREES

The 2214 engineers and architects who gave a complete academic record received 3914 academic and honorary degrees, or an average of almost two degrees each.

They have received (see Table 4), 1417 degrees in branches of learning other than scientific. Of these, 38.1 per cent were in liberal arts, 19.1 per cent in philosophy, and 8.9 per cent in law.

The scientific degrees total 2497, of which 75.2 per cent are bachelors', 69 per cent masters' and 39.8 per cent doctors' degrees.

These data show the wide range of interest and training of these men. They should be sufficient to refute the often-repeated thought that engineers are narrow in their training and interests and are deficient in cultural development.

A larger number have degrees of Doctors of Philosophy, Science, and Laws than have the degree of Doctor of Engineering. This may mean that the profession has been slow to recognize and to honor notable men of the profession.

TABLE 4 ACADEMIC AND HONORARY DEGREES

	Number	Per cent
Total number of engineers and architects	2,124	100.0
Liberal Arts		
Bachelor of Arts	458	21.6
Master of Arts	317	14.9
Bachelor of Philosophy	121	5.7
Doctor of Philosophy	289	13.6
Bachelor of Letters	7	0.3
Doctor of Letters	16	0.8
Doctor of Fine Arts	4	0.2
Bachelor of Laws	39	1.8
Doctor of Laws	150	7.1
Doctor of Divinity	4	0.2
Science		
Bachelor of Science	883	41.3
Master of Science	190	8.9
Doctor of Science	283	13.3
Doctor of Medicine	12	0.6
Doctor of Chemistry	5	0.2
Engineering		
Bachelor of Engineering	86	4.0
Master's Degree in Engineering	955	44.9
Doctor of Engineering	86	4.0
Architectural		
Bachelor of Architecture	6	0.3
Master of Architecture	3	0.1

HONORARY FRATERNITIES

There are four honorary fraternities, membership in which connotes noteworthy and outstanding achievement either before or after graduation. Phi Beta Kappa and Phi Kappa Phi

recognize notable accomplishment in the general field of human endeavor. The Sigma Xi fraternity recognizes scientific merit, and the Tau Beta Pi rewards engineering scholarship and leadership.

In the groups being considered 588 hold 905 memberships in these fraternities. The majority of the 588 are members of two or more of the fraternities, many are members of three, and some are members of all four. The 905 memberships are thus distributed: Sigma Xi, 66.2 per cent; Tau Beta Pi, 45.8 per cent; Phi Beta Kappa, 31.0 per cent; and Phi Kappa Phi, 10.1 per cent.

Membership in Scientific Societies

A measure of a man's professional attainment, recognition, and loyalty is the memberships he holds in professional societies, The group being considered hold 5278 memberships in 38 of the most prominent engineering, scientific, and technological societies—an average of more than two societies per man. They also hold 186 memberships in six British societies.

The memberships of 1767 of these men are thus distributed among the larger engineering societies:

American Society of Civil Engineers.....35.0 per cent
American Society of Mechanical Engineers.....30.5 per cent
American Institute of Mining and Metallurgical Engineers.....28.9 per cent
American Institute of Electrical Engineers.....23.0 per cent

There are 308 men who are members of two or more of the above-named societies; 54 are members of three; 2 are members of four.

Classification of Associations, Commissions, Boards, Conferences, and the Like of Which Engineers and Architects Are Members

The charge has been made that engineers are overspecialized; that they are uncultured. Presumably if they are overspecialized they would not be particularly interested in activities lying without their specialty, nor would they be welcomed within other circles. If they are uncultured, presumably they would not be interested in art, civics, history, literature; nor would they be concerned with activities lying without their restricted geographical area. If these presumptions are correct, then the evidence presented in Table 5 refutes the charge that engineers are overspecialized and uncultured. What is the evidence? It is that these men hold membership in 1138 associations, commissions, conferences, and the like, half of which are nontechnical; that the activities of these organizations touch practically every interest of mankind; that these organizations are not restricted geographically, but are located in many parts of the world. The geographical distribution of these organizations is of interest. It is as follows:

National.....38.4 per cent
State.....20.6 per cent
Foreign.....17.5 per cent
Municipal.....16.1 per cent
International..... 7.5 per cent

Classification of Activities

A general classification of the activities in which the 2858 engineers and architects are engaged appears in Table 6.

The percentages total more than 100 per cent because some of the men were placed in more than one group. The number in each classification represents those whose major activity is that assigned. Subsidiary positions as officers of banks, hospitals, libraries, and the like were not included. This information will appear in a subsequent table.

It will be observed that 38.4 per cent of the group are officers of industrial and commercial companies. By officers is meant presidents, vice-presidents, general managers, directors of research, chief engineers, and equivalent positions. Consulting engineers and members of consulting-engineering firms comprise 27 per cent of the total, and educators, 21.9 per cent. The three groups, i.e., officers, consultants, and educators, account for 87.3 per cent, and those in municipal, state, and federal service for 10.9 per cent of the total.

Of the entire group 37.1 per cent are available for consultation, 34.8 per cent have made contributions to scientific and technical literature, and 6.9 per cent have been editors of technical papers.

Among the number are editors of technical journals, inventors, lawyers, authors, lecturers, explorers, newspaper editors, managers of trade associations, clergymen, farmers, magazine editors, photographers, an art dealer, a gem expert, a missionary, and secretaries of engineering societies.

TABLE 5 CLASSIFICATION OF ORGANIZATIONS IN WHICH ENGINEERS AND ARCHITECTS HOLD MEMBERSHIP

Class	Number of societies
Agriculture	25
Art, including architecture	96
Civic	79
Commerce, and trade, including manufacturing and transportation	120
Economics	18
Education	42
Employers	8
Engineering	149
Health	18
Historical	40
Labor	10
Legal	11
Literature	20
Medical	19
Military	53
Patriotic	25
Philosophical	3
Political	47
Religious	9
Scientific, including engineering, architectural, and medical	579
Social science	35
Sports	4

TABLE 6 CLASSIFICATION OF ACTIVITIES

	Number	Per cent
Total number	2,858	100.0
Officers of industrial and commercial companies	1,095	38.4
Consultants	772	27.0
Educators	626	21.9
United States government service	183	6.4
Municipal government service	68	2.4
Editors of technical journals	66	2.3
State government service	59	2.1
Inventors	41	1.4
Lawyers	33	1.2
Authors	29	1.0
Lecturers	14	0.5
Secretaries of engineering and scientific societies	14	0.5
Explorers	11	0.4
Newspaper editors	4	0.1
Managers of manufacturers' associations	3	0.1
Clergymen	3	0.1
Farmers	2	*a*
Magazine editors	2	*a*
Photographers	2	*a*
Art dealer	1	*a*
Gem expert	1	*a*
Missionary	1	*a*

a Less than 0.1 per cent.

Classification of Organizations in Which Engineers and Architects Are Officers

This assay shows that the 2858 engineers and architects hold 4785 official positions in 3928 different organizations. They occupy the position of president in 1128 industrial and commercial organizations, 72 engineering firms, 68 banks and trust companies, and 23 colleges and universities. The distribution of the 4785 official positions is shown in Table 7.

Classification of Industrial and Commercial Companies in Which 3493 Official Positions Are Held by Engineers and Architects

The 2993 industrial and commercial companies officered by engineers and architects cover the entire industrial and commer-

TABLE 7 CLASSIFICATION OF ORGANIZATIONS IN WHICH 4785 OFFICIAL POSITIONS ARE HELD BY ENGINEERS AND ARCHITECTS

	Number of organizations	Presidents	Vice Presidents	Chairmen of boards	Directors or trustees	Members of firms	Managers	Chief engineers	Superintendents
Architect firms	135	6	1	1	1	142	...	...	...
Banks, trust and investment companies	474	68	41	10	414	...	8	3	...
Colleges and universities	86	23	2	4	98	...	...	...	...
Engineering firms	110	72	26	4	26	104	6	6	...
Hospitals	38	6	...	...	29	...	3	...	...
Hotels	3	...	...	...	3	...	...	...	...
Industrial and commercial companies	2,993	1,128	647	117	909	...	271	303	118
Law firms	5	...	...	...	...	5	...	...	...
Libraries	20	2	...	...	18	...	...	...	...
Museums	7	1	...	...	6	...	...	...	...
Opera companies	3	1	...	...	2	...	...	...	...
Private and secondary schools	50	13	1	...	36	...	...	...	...
Theaters	4	...	...	...	4	...	...	...	...
Total	3,928	1,320	718	136	1,546	251	288	312	118

TABLE 8 CLASSIFICATION OF INDUSTRIAL AND COMMERCIAL COMPANIES IN WHICH 3493 OFFICIAL POSITIONS ARE HELD BY ENGINEERS AND ARCHITECTS

	Number of companies	Presidents	Vice-Presidents	Chairmen of boards	Directors or trustees	Managers	Chief engineers	Superintendents
Aerial transportation	6	4	...	...	2	...	...	...
Aircraft	11	6	2	1	2	...	1	...
Automobiles	45	27	11	4	10	1	4	1
Bus transportation	4	...	...	...	3	...	1	...
Cement	17	7	2	1	4	4	1	...
Ceramic products	16	6	1	...	6	1	2	...
Chemicals	97	46	15	2	32	9	...	1
Coke	18	6	5	2	6	2	...	...
Construction	89	42	20	5	13	8	12	2
Electric equipment	135	51	40	10	44	7	18	6
Exporting and importing	18	5	2	1	8	2	...	...
Farming	7	2	...	1	2	2	...	...
Fine machines and instruments	13	2	3	...	8	1	1	...
Food products	21	5	3	...	12	1	1	...
Gas and electric light and power	357	123	95	18	106	17	21	13
Ice	5	1	...	1	2	1	...	...
Insurance	49	5	3	1	40	1	1	...
Iron and steel	75	37	21	2	16	7	5	8
Leather	6	2	...	...	4	1	...	...
Lumber	24	4	9	1	8	...	2	...
Machinery and metal working	269	113	37	16	101	20	17	2
Mining	267	86	50	4	55	62	7	35
Paint	4	1	...	...	2	1	...	...
Paper and pulp	14	6	3	2	2	...	1	...
Petroleum	105	40	23	5	39	4	1	...
Printing and publishing	48	25	10	3	15	6	...	...
Railroads	280	86	75	8	82	19	128	16
Realty	98	51	12	1	25	6	3	...
Retail	6	5	...	...	1	...	...	...
Rock products	13	5	4	...	3	1	...	...
Rubber	15	8	2	2	5	...	...	...
Shipbuilding	32	21	8	1	3	3	2	1
Smelting and refining	117	41	21	...	39	29	7	16
Street railways	129	53	26	4	22	13	18	7
Sugar	7	2	3	...	2	...	...	...
Telephone and telegraph	61	21	31	1	25	2	10	2
Textiles	47	17	4	4	20	...	2	...
Water supply	44	20	8	2	10	1	8	...
Water transportation	35	11	11	1	11	4	4	...
Wood products	9	2	2	...	4	1	...	...
Unclassified	380	133	85	13	115	34	24	8
Total	2,993	1,128	647	117	909	271	303	118

cial range of American life as disclosed by Table 8. Among these companies are some of the largest, wealthiest, and most influential in their respective groups.

The remark is frequently made that the engineer is not a good executive; that he knows how to design and operate, but he is not a successful administrator. If this be true, is it not amazingly strange that out of only 2858 engineers, 1128 positions such as presidents of leading industrial organizations are occupied by them? If this be true, is it not amazingly strange that 848 of the companies in question have assets totaling more than 90 billions of dollars? If this be true, is it not amaziugly strange that 683 of the companies realized gross earnings of over 17 billion dollars in 1928?

The assets of the banks and trust companies included in this analysis represent one-quarter of the total assets of the 26,213 banks in the United States.

The current assets of all the railways of the United States, according to the Interstate Commerce Commission, are, in round numbers, 27 billion dollars. Those railways officered by engineers have assets of over 24 billion dollars.

An effort was made to obtain the total assets and gross earnings of the 2928 organizations officered by engineers and architects. The assets were obtained for only 848 companies and the gross earnings for only 683. These data are given in Table 9.

TABLE 9 TOTAL ASSETS OF 848 COMPANIES, AND TOTAL GROSS EARNINGS OF 683 COMPANIES

	Total assets		Total gross earnings	
	No. of Cos.	Amount in 1928	No. of Cos.	Amount in 1928
Banks and trust companies	116	$18,951,795,706	46	$ 332,146,966
Industrial companies	359	19,556,072,853	264	9,723,548,907
Insurance companies	23	7,288,747,547	23	1,745,928,271
Public utilities	218	20,978,314,727	218	3,971,678,577
Railways	132	23,959,131,316	132	2,153,520,887
	848	$90,734,062,149	683	$17,926,823,608

EDUCATIONAL INSTITUTIONS

Educational institutions engage the activity of 21.9 per cent of the group being studied. Their distribution according to position is shown in Table 10.

TABLE 10 POSITIONS IN EDUCATIONAL INSTITUTIONS

	Number	Per cent
Total number of engineers and architects	2,858	100.0
Number of positions in educational institutions	626	21.3
College professors	407	14.3
College deans (including deans of engineering)	151	5.3
Deans of engineering	94	3.3
College presidents	48	1.7
Principals of private schools	7	0.2
Directors of museums	6	0.2
Librarians	5	0.2
College treasurer	1	*a*
College business manager	1	*a*

a Less than 0.1 per cent.

PUBLIC SERVICE

Some measure of the penetration of science into American life is shown by the positions of trust held by scientific men in municipal, state, and federal service. Over one-half, 52.1 per cent, of the men under consideration have served or are now serving municipal, state, or federal governments.

CITY GOVERNMENT

City governments have been served by 208 of these men. Among them have been 68 city engineers, 18 mayors, 6 city managers, 3 chiefs of police, and 2 superintendents of city schools.

STATE GOVERNMENT

State governments have engaged the efforts of 269 of the group at some time during their careers, 59 of whom are now in state work. There have been 10 governors, 5 legislators, and a state district attorney among them. The present governors of Delaware, Utah, Wyoming, New Jersey, Alaska, and Alabama are engineers. The governors of North Carolina and Indiana hold the degree of bachelor of science.

FEDERAL GOVERNMENT

The information contained in Table 11 is significant. It shows that 35.4 per cent of the 2858 engineers and architects have served the Federal Government in many responsible capacities, and that

the breadth of their service has covered most of the important interests and relationships of the Government. This indicates a versatility of capacity and ability which belies the charge that scientific men are overspecialized.

Present-day conditions are not fully depicted by the information contained in Table 11. Many things have happened since the material in "Who's Who" was prepared for publication. So significant have been the developments that it is necessary to digress from the basic source of information in order to present a more complete picture of the present place of men of science in

TABLE 11 UNITED STATES GOVERNMENT SERVICE

	Number	Per cent
Total number of engineers and architects	2,858	100.0
United States Government service at some time during career	1,101	35.4
Military service of United States Government at some time during career	448	15.7
United States Government service at present time	185	6.4
Consul	9	0.3
Commercial or military attaché	8	0.3
Congressman	7	0.2
Senator	6	0.2
Ambassador	4	0.1
Cabinet member	2	*a*
Director of Mint	2	*a*
President of the United States	1	*a*
Vice-President of the United States	1	*a*
Director of Observatory	1	*a*

a Less than 0.1 per cent.

the federal service. To begin with, the President of the United States is an engineer, and he is no less an engineer because he is President. This you should remember: That Herbert Hoover is a devoted and loyal member of the engineering profession. He appreciates the accomplishments of the profession and thoroughly enjoys association with "my fellow-engineers," as he speaks of them.

The Secretaries of the Interior and Commerce are scientific men—the one an eminent physician, the other a distinguished engineer.

The Director of the Budget is an engineer, a position equivalent to a Cabinet portfolio.

To name the various branches of the Federal Government in which engineers hold responsible positions would be to catalog the activities of the Government. Suffice it to say that, as measured by the participation of scientific men in the affairs of the Federal Government, no other one group is more influential in shaping the destiny of the nation.

The people of the United States are a peace-loving people. They are a people who are moved by the sufferings of mankind. They are a people who have expended their means and their lives to relieve the inequalities and the wrongs visited upon others. When necessary they have gone to war—not for a selfish purpose, but that men might be free. That engineers and architects in a like manner are touched by human suffering and need, that they in a like manner respond to the call to make men free, is evidenced by the fact that 448 of the group being considered have served in the military forces of the Government. That they serve willingly and ably is shown by the ranks they held. Among them were 13 major-generals, 39 brigadier-generals, 63 colonels, 73 lieutenant-colonels, 88 majors, and 58 captains. In the naval service there were 24 rear-admirals, 2 commodores, 2 captains, 11 commanders, 11 lieutenant-commanders, and 6 lieutenants.

FINDINGS

This assay has disclosed:

That of the 28,805 "notable living men and women of the United States" named in "Who's Who in America" (1928–1929), men of science comprise 30.4 per cent; lawyers, 15.2 per cent; and physicians and surgeons, 7.3 per cent.

That the 2858 engineers and architects received 1417 academic degrees in branches of learning other than science.

That these engineers and architects received 2497 scientific degrees.

That 588 of these men hold 905 memberships in Phi Beta Kappa, Phi Kappa Phi, Sigma Xi, and Tau Beta Pi.

That the 2858 engineers and architects are members of 1138 associations, conferences, boards, and commissions, half of which are non-technical.

That they hold 4785 official positions in 3928 organizations, of which number 2993 are industrial and commercial companies.

That they occupy the position of president in 1128 industrial and commercial organizations, 72 engineering firms, 68 banks and trust companies, and 23 colleges and universities.

That among these 2858 engineers and architects there are, or have been, 10 governors, 13 members of Congress, 2 members of the Cabinet, and the President of the United States.

CONCLUSIONS

The findings of this assay clearly show that engineers and architects are versatile, not narrow; internationally, not provincially minded; leaders, not followers; scholarly, not unlearned; cultured, not rude; humane, not cruel; lovers, not haters of mankind.

It would appear that the journey pictured for the profession by Drs. Hadley and Keyser is proceeding, and that the hope and the promise they expressed are being fulfilled. For the indications are that the men of science are becoming the organizers and directors of the civilizing energies of the world in the interest of all mankind. However inspiring and satisfying these indications may be, they should not be permitted to flatter the vanity of the members of the profession but rather impart a feeling of humility. For be it remembered that Dr. Keyser said his ideal for the profession is one which it will approximate more and more just in proportion as it becomes more and more humanized and enlightened.

A similar warning has been voiced by Mr. Erhard, a brilliant young lawyer of Texas. Mr. Erhard said: "I only hope that the engineer, with all his efficiency, zeal, and Promethean accomplishments will not dehumanize his profession. His structures must, after all, reflect not only the glory of his science and art, but the comfort, well-being, and happiness of his fellow-man. Even as he thinks in terms of steel and concrete, he must sense the still, sad music of humanity and embrace with his vision a world always yearning and reaching for leadership, a type of leadership which will be sympathetic, encouraging, and strengthening."

Therefore it appears that the challenge to the profession is to supply that type of leadership, and if it does, then in the years to come it can be truly said of us,

> For these maintain the fabric of the world,
> And in the handiwork of their craft is their prayer.

Deposits of chromium on brass or iron are often faulty due to errors in the preliminary deposition of the nickel, according to Herr W. Phanhauser, in a recent issue of *Chemiker-Zeitung*. The evolution of hydrogen in the deposition of chromium and the absorption of hydrogen in the metal cannot be avoided. As the hydrogen readily diffuses from the chromium into the nickel, the capacity of the latter for the gas is exceeded. This results in brittleness, non-adhesion, and in peeling, partly during the application of chromium and partly soon afterward. Thus it is important to deposit a nickel coating as low in hydrogen as possible. Insufficient removal of grease from the brass before the application of the nickel causes blisters in the chromium plating.—*The Engineer*, October 18, 1929, p. 413.

The Metalclad Airship

Advantages Obtained From All-Metal Construction—Particulars Regarding Design, Construction, Erection, and Assembly of the U. S. Navy Dirigible "ZMC-2," Together With Data on Dimensions, Weight Arrangement, and Performance

By CARL B. FRITSCHE,[1] DETROIT, MICH.

THOSE who have had the good fortune to study the craft must be impressed with the immensely useful field in aerial transportation open to the dirigible airship. With its large weight-carrying capacity; its safety; its increasing speed; its long range; its improvement in efficiency with size; its comparative economy in operation and the fact that the air is "open" in all directions; it is no idle prophecy to visualize a network of airship lines encircling the globe, supplementing our present land and water transport facilities, and penetrating remote regions of the world now little known to civilized man.

The sheer economy of this service will dictate its accomplishment. Think of a fuel cost per passenger for crossing the Atlantic in a super-airship of only $20 and of a fuel cost per passenger for flying from New York to Chicago of only $5, or but little more for fuel per passenger-mile than for touring in a $4000 automobile!

FIG. 1 METAL DIRIGIBLE "ZMC-2" TAKING OFF ON FIRST FLIGHT
(Gross Ile Airport August 19, 1929. Flight lasted 49 min.)

Encouraged by the availability of dependable engines, of light, thin alloys, and of seasoned engineering talent, the Aircraft Development Corporation was organized in 1922 to modernize the rigid airship, already a metal-framed structure since 1900, and make it all-metal like the hull of a seagoing vessel, which seemed an obviously desirable step. For five years engineering research and study was carried on, at a total expense exceeding $300,000. It was discovered that not only can an airship be built possessing all of the obvious advantages of all-metal construction, but, contrary to common belief, that metalclad construction in the larger sizes does not add considerably to the weight as compared with fabric construction.

The metalclad ship is a single structural unit in which the surface plating carries a considerable portion of the direct stresses. The metal plating, which is the outer cover, is the principal strength member and is also the gas container.

All-metal construction seems, therefore, to assure fulfilment of the world-wide demand for a commercial airship in which the public will have more confidence. Such an airship must be:

Fireproof
Weatherproof
Durable and permanent in structure
Navigable in practically all kinds of weather
Economical in the use of buoyant gas and ballast
Capable of high speed up to at least 100 miles per hour, and
Limited in cruising range only by the expanse of our broadest ocean.

All will understand that these ideal specifications do not apply to the first experimental unit, the *ZMC-2*, which is entirely too small to comply in detail with such high standards. In performance characteristics it is similar to the non-rigid fabric blimp, but in the magnitude of its importance as an engineering achievement, it is at least equal that of any rigid airship ever built.

Its size of 200,000 cu. ft. was determined upon as sufficient to fulfil Government experimental requirements.

The *ZMC-2*, as the Navy has designated this first unit, made its first trial flight on August 19. It was delivered to Lakehurst on September 12, and on September 16 it completed successfully its final test, exceeding all contract specifications. Its general characteristics and performance data are given in Tables 1 and 2.

DESCRIPTION OF THE "ZMC-2"[2]

THE HULL

The *ZMC-2* hull is 149 ft. 5 in. long from bow to stern, and 52 ft. 8 in. in maximum diameter. Its covering consists of 0.0095-in. thin Alclad alloy sheets sewed together by the Aircraft Development Corporation riveting machine. Each of the rings of sheet metal composing the hull surface has the shape of the frustum of a cone; together the cones closely approximate the curvature of the hull. There are 142 such conical surfaces from bow to stern.

The skin contains lifting gas, consequently the seams and rivets have to be gasproof. This is achieved by a gas-sealing compound which is applied on the seams, is drawn in by capillary action, and seals the lap seam.

[1] Vice-President, Detroit Aircraft Corporation; President, Aircraft Development Corporation. Mem. A.S.M.E.

Presented at the Third National Meeting of the A.S.M.E. Aeronautic Division, St. Louis, Mo., May 27 to 29, 1929. The abridgment here published is confined largely to the descriptive portions of the text. The complete paper, which also deals at length with the economic questions involved, is too extended for publication in MECHANICAL ENGINEERING, but will appear later in *Aeronautical Engineering* (Trans. A.S.M.E.), brought up to September 20, 1929, after the airship had completed its final test flights.

[2] Chapter in Appendix; prepared by W. A. Klikoff, Vladimir Pavlecka, and S. A. U. Rasmussen, Detroit Aircraft Corporation, Detroit, Mich.

TABLE 1 GENERAL CHARACTERISTICS OF THE "ZMC-2" AIRSHIP

Length of hull	149 ft. 5 in.
Diameter of hull (max.)	52 ft. 8 in.
Fineness ratio	2.83
Displacement of hull	202,200 cu. ft.
Total ballonet displacement	50,600 cu. ft.
Front ballonet displacement	22,600 cu. ft.
Rear ballonet displacement	28,000 cu. ft.
Ratio of ballonet volume to hull volume	25 per cent
Thickness of skin	0.0095 in.
Length of car	24 ft.
Width of car	6 ft. 6 in.
Number of air valves	3
Number of gas valves	2
Number of fins	8
Total fin area	440 sq. ft.
Total elevator area	190 sq. ft.
Total rudder area	95 sq. ft.
Total automatic rudder area	95 sq. ft.
Engines (Wright "Whirlwind" J-5)	2
Power at 1800 r.p.m	440 hp.
Propeller diameter (all-metal)	9 ft. 2 in.

TABLE 2 PERFORMANCE DATA—"ZMC-2" AIRSHIP

Gross lift (100 per cent inflation with 92 per cent pure helium at 60 deg. fahr. and 29.92 in. Hg)		12,242 lb.
Weight empty		9,115 lb.
Useful load		3,127 lb.
Crew (three)	600 lb.	
Fuel (200 gal.)	1,200 lb.	
Oil (25 gal.)	200 lb.	
Ballast (50 gal.)	420 lb.	
Passengers and cargo	707 lb.	
Range with 250 gal. fuel (cruising speed)		680 miles
Maximum possible range (still air)		1,000 miles
Maximum speed at 440 hp		62 ± 2 m.p.h.
Cruising speed at 220 hp		50 ± 2 m.p.h.
Static ceiling		9,000 ft.

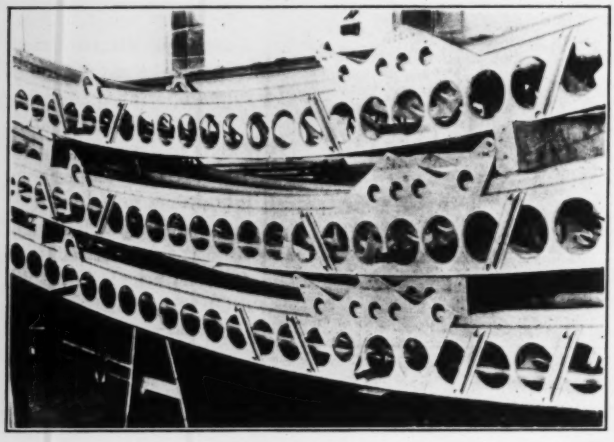

FIG. 2 GIRDERS READY TO BE ASSEMBLED AS PART OF FRAMEWORK OF DIRIGIBLE

Inside the hull the skin is held firmly by rivets to a supporting structure built up of transverse frames and longitudinals. There are 24 equally spaced longitudinals running from the bow to frame No. 145, and 16 from this frame to the stern. In the bow and the stern is a rigid ring from which the longitudinals radiate. Incidentally these rings serve also the purpose of manhole frames, as will be mentioned later.

The cross-section of the longitudinals is of the "capital omega" type (Ω). The flanges of the section are attached to the skin by rivets. Two sizes of section are used. In the extreme bow and stern, where the longitudinals are crowded, the section is only 1 in. high, while the rest of the hull has longitudinals 2 in. high. The latter are lightened and strengthened by flanged holes.

The thickness of longitudinals varies from 0.014 in. to 0.032 in. according to the intensity of compressive loads in any particular portion of the hull.

TRANSVERSE FRAMES

There are altogether 12 transverse frames, numbered according to their distance from the bow of the hull. Of these, frames Nos. 18, 54, 70, 114, and 122 are of the heavy built-up type, the remainder being of simple triangular cross-section.

The main frames are also of a substantially triangular cross-section, having all three apexes formed by channels and mutually connected by light webplates and a baseplate. Flanged holes are used liberally in the channels, webs, and baseplates. In cross-section the frames are 8 in. high on center line and from 8 to 10 in. wide at the base, depending on the base slant, which corresponds to the angle of the skin at the location of the frame. The channels are 0.025 in. in thickness, the webs, 0.020 in., and the baseplate, 0.014 in.

Each frame is built up of a number of bowed sectors spliced

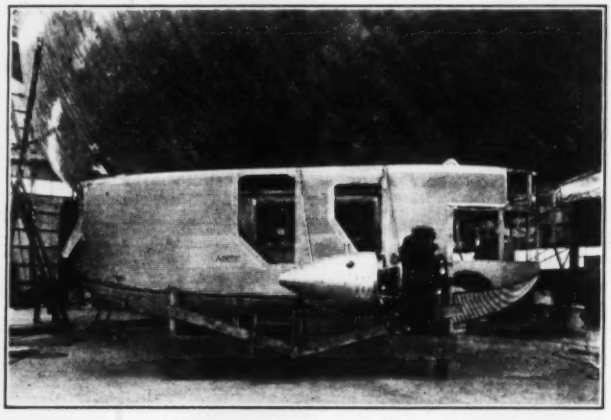

FIG. 3 SIDE VIEW OF CAR AND MOTOR MOUNT ON THE "ZMC-2"

end to end. The main frames take primarily all concentrated loads, such as landing and handling lines, weight of the car, fin loads, etc. They are diagonally wired by hard-drawn aircraft wire and tie rods. Wires are spliced to eyebolts screwed into Lynite castings as filler blocks, which in turn are anchored in the apex channel of the frames. Gusset plates or, as in the fin attachments, tubular spacers are employed to transmit the external loads from the base of the frames to the apex.

The outer bolts, on which the outside loads are applied, pass through heavy reinforcing plates on the inside of the hull skin; in addition, cast bearing blocks hold the bolts on these baseplates against tangential loads. Gastightness at such joints is achieved by a gasket of canton flannel treated with the same compound as the seams.

In addition to the load wiring, the frames 54 and 70 have, in their lower halves, auxiliary wiring to take the loads imposed by the ballonet diaphragm.

The frames are continuous, while the longitudinals stop at the frames and are connected through the frames by special straddling splices of formed sheet. In addition to the main longitudinal and transverse structure described above, there are rigid diagonals at places of considerable shear stresses as on the side of the hull, and in auxiliary ribs in locations where stiffness is desired, as on the bottom of the hull. All these reinforcements employ a 2-in. channel section, and all are rigidly connected to the rest of the structure by means of baseplates and splices.

The average spacing of rivets attaching the skin to the structure is 2 in. Flat-headed rivets of $^3/_{32}$ in. diameter with round edge are used, which eliminates cutting of the skin by the sharp edge of customary round-head rivets. All rivets are of 17S aluminum alloy.

The bow and stern are fitted with manholes, covered normally with a metal shield plate, screwed down. Similar manholes are placed at all main frames on top of the hull, to facilitate entrance

into the hull for adjustment or repairs. These manholes, 5 in all, are provided with a fabric seal against leakage. The rear ballonet can be entered by a similar manhole in the bottom of the hull.

VALVES

The hull is equipped with 5 valves, automatically as well as hand operated, of the Gammeter type, 20 in. in diameter and having a 4-in.-water-column maximum blow-off pressure. Two of the valves are for gas and three for air, the latter being at the

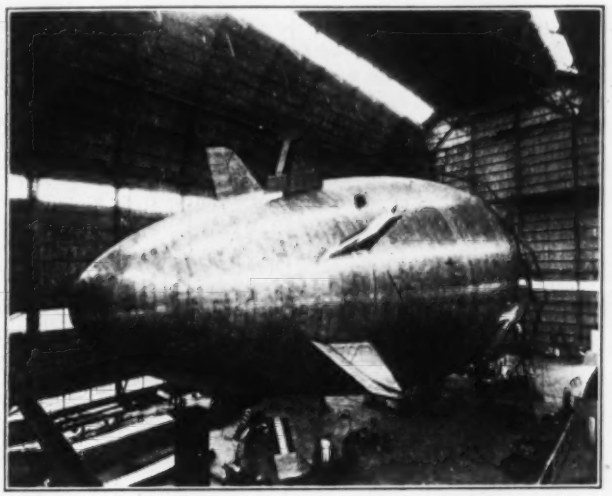

FIG. 4 VIEW OF THE "ZMC-2" SHOWING SERIES OF CONTROL FINS WHICH EMBODY A NEW PRINCIPLE IN AIRSHIP DESIGN

bottom of the hull. One of the gas valves is on the port side of the hull, and the other in the stern at the bottom of the hull.

Two gas-replenishing connections of 15 in. diameter each are built into the bottom of the hull, one in the bow and the other in the stern. All of these holes and valve seats require secondary structure for local reinforcement, and 2-in. channel is used for this purpose.

The largest unsupported area of the hull skin occurs at the maximum diameter and is 6 ft. wide by 15 ft. long.

Three pairs of glass inspection windows are located in the bow, port side, and stern of the ship, respectively.

On the underside of the bow is a triangular rip panel which can be torn open by the pilot in an emergency; it operates on the principle of shearing the skin against the edges of two thick strips.

Control cables to the gas valves run in Bowden casings, securely cemented to the surface of the hull. The air resistance of this type of controls is negligible.

HANDLING LINES

The *ZMC-2* is equipped with four sets of steel-cable handling lines; each set has two lines, attached to the hull symmetrically to the ship's center line. Each of these lines is designed for 5600 lb. ultimate strength.

One set, on the bow, is intended for landing the ship. Two sets, one on the bow and the other on the stern, are intended for handling the ship on the ground. The last set, located amidships, is designed for holding the ship against rolling when on the ground.

The landing lines are each 40 ft. long, with cotton-rope extensions. In addition, a third landing rope is carried; this is a $^3/_4$-in.-diameter manila, 250 ft. long, which can also be used as a drag rope. This rope is attached to the bottom of the control car and can be dropped at the pilot's will. By a quick-release device it may be swung to a bridle on frame 18 of the hull.

THE CAR

In plan view the car has a smooth curve, which provides most floor space for the general car dimensions. In cross-sectional view the bottom is a semi-octagon with its vertical sides extended up to the top of the car. The car is 24 ft. long and 6.5 ft. wide at maximum section. With scoops, tanks, controls, radio, drag rope, blower, and a chart table installed inside, it still is quite roomy for two pilots, one mechanic, and about four student pilots.

The structure of the car consists of eight transverse frames, a number of longitudinals, and diagonal braces. It is a bridge-like structure and has been analyzed as such.

The covering is of 0.014-in. corrugated Alclad sheet. The chines, 4 in all, are very rigid, and together with the plating add considerably to the strength of the structure.

All frames are box girders, trussed with inside channels, and each frame is designed for the particular loads it takes. The heaviest frame weighs 33 lb., and the highest load occurring in it is 17,000 lb. compression.

The basic rolled section used in the car is a U-channel with flanges, 2 in. wide and $2^1/_2$ in. high. Flanged holes are used profusely in all except the tension members.

The car is suspended to the hull by means of eight attachments; of these four are rigid joints and four streamline rods. Either of these two sets of joints is designed to carry independently the car with all loads in it. Furthermore, the rigid joints are called

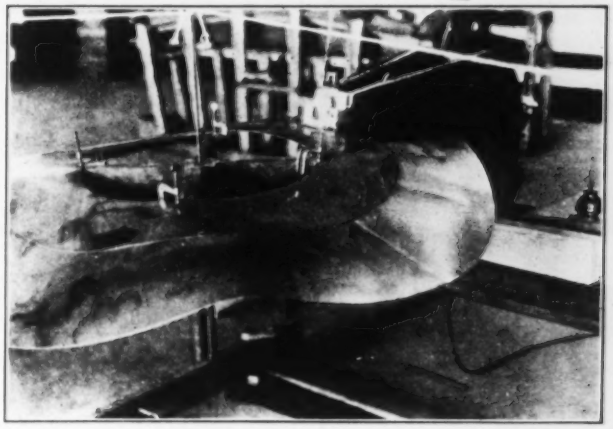

FIG. 5 FIRST STEP IN CONSTRUCTING THE DIRIGIBLE "ZMC-2"—RIVETING THE NOSE PLATES

upon to take the thrust of the power plants. The factor of safety of all joints is 6 on the highest load each joint might ever be required to carry.

The pilots sit side by side in the bow of the car, with all controls and instruments on a panel in front of them. Directly above their heads is a compartment containing a dynamic scoop.

The altitude pilot, seated on the port side, can operate a radio set immediately behind him on a desk. The direction pilot, on the starboard side, can read maps on a chart table placed opposite the radio desk.

The engine outriggers are mounted to the car aft of the pilots, with propellers behind the pilots' seats. In the middle portion of the car are propeller scoops and vertical ducts, one on each side of the car. In this section also is the mechanic's post with a board of engine instruments and controls.

All engine-control rods are carried in the double bottom of the car and are easily accessible.

The pilots can control engine speed by their own set of throttles in addition to the mechanic's controls.

The entrance door is on the starboard side, behind the propeller scoops. Opposite the entrance is a hand air blower for maintaining the hull pressure in an emergency. Besides the main door there are four hatches, one for each pilot and two for the mechanic, to gain access to the engines during flight. A walkway is built on the engine outriggers to connect the car with the nacelles.

The stern of the car is taken up by the tanks. Two gasoline tanks, 100 gal. each, are placed in tandem on special cradles. The rearmost tank is of 50 gal. capacity, to be used as a water-ballast container. It can, however, be connected to the fuel system and used as a gasoline tank for long flights.

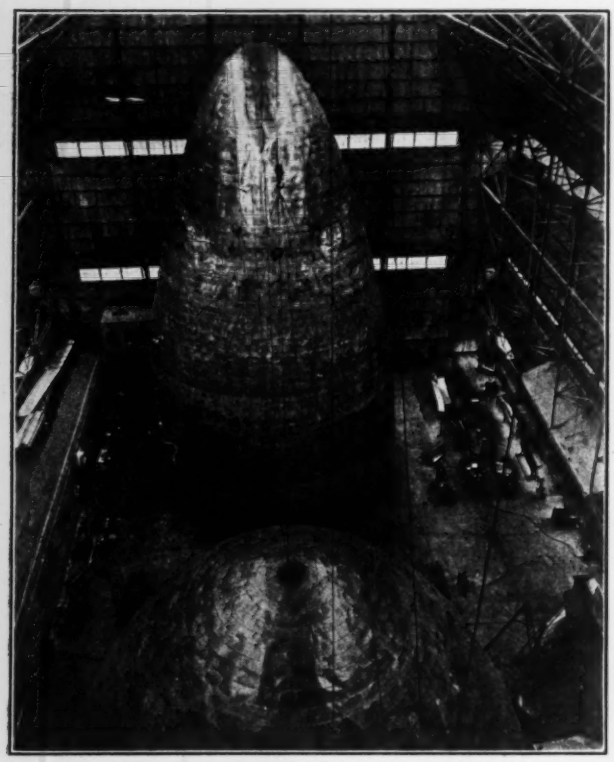

FIG. 6 SHOWING VERTICAL METHOD OF ERECTION USED DURING CONSTRUCTION OF DIRIGIBLE

All tanks have dump valves.

Special balsa plywood flooring is laid in the car and fastened solidly to the structure, except in a few places, where it is removable to gain access to control rods and cables.

Electric light is supplied by a 12-volt storage battery.

POWER PLANTS

The engines are carried on tubular outriggers, one on each side of the car. Wright "Whirlwind" J-5-A engines are used, developing a maximum of about 220 hp. each. They operate tractor metal propellers. Each power plant has independent fuel, oil, and ignition systems and controls.

The oil tank, with a glass volume gage, is located inside the streamline nacelle behind each engine. Oil pressure and temperature gages are on the mechanic's board inside the car. All controls, tubes, and ducts to the engines are inside a walkway leading to each engine. A push-and-pull system is used for engine controls.

Each outrigger can be detached from the car by removing four bolts and disconnecting the instrument leads, pipes, and controls. The engines have inertia starters, hand operated from inside the car through the hatches.

THE LANDING GEAR

A bumper bag for taking landing shocks was out of the question in the case of the *ZMC-2*, due to the low position of the engines and excessive height of the car above the ground.

The landing gear is an inverted tripod with one leg as a shock absorber of the Oleo type; the other two legs are streamline duralumin tubes. The impacts are received by a streamline, hollow steel shoe at the apex of the tripod. The streamline struts are calculated for a factor of safety of only 2. In case of a severe shock these struts are expected to collapse, and in doing so check the inertia of the hull, thus eliminating the danger of damaging the car. This appears to be the only practical solution of the problem of protecting both the car from ground impact and the hull from the car.

THE BALLONETS

Two ballonets, one of 22,600 cu. ft. and the other of 28,000 cu. ft. capacity, are located between frames 18 and 54, and 70 and 114, respectively. These ballonets are made as complete fabric bags laced to the above-mentioned main frames and also to the longitudinals. The bags are so designed that practically all loads due to surging and to pressure are transmitted to the main frames.

The ballonets are made of two-ply rubberized fabric weighing 9 oz. per sq. yd. The seams are pulled $^3/_4$ in.—cemented and taped but not sewn. The ends and sides of the ballonets are attached to the main frames and longitudinals by lacing strips with grommets. The bottoms are tied to the intermediate crossings of longitudinals and frames in order to prevent the possibility of gas getting under the ballonet and lifting it while surging. Around the various openings leading through the bottom of the hull, the ballonets are cemented to the hull with "Vulcalock."

Air is supplied to the ballonets through a scoop located in the forward end of the car and two propeller scoops. For ordinary conditions of level flying the car scoop should be sufficient, as it automatically increases the air pressure in the ballonets with the increase of the speed of the ship. The scoops are so controlled that air can be let into either ballonet independently or into both ballonets at the same time. An auxiliary hand blower with a maximum capacity of 2200 cu. ft. per min. is provided in the car. This pump should take care of a descent of 250 ft. per min.

One automatic and hand-operated air valve and one automatic emergency air inlet are provided for the forward ballonet and two of each for the rear ballonet. The air valves are standard 20-in. Gammeter airship valves. The air inlets are inward-opening, non-return fabric flaps. To prevent leakage they are sealed with easily ripped fabric covers.

A rip panel is located in the rear end of the forward ballonet and another in the forward end of the rear ballonet, to open the ballonets into the gas space.

FINS

A group of eight fins and control surfaces are located at frame No. 122, all surfaces being equally spaced around the hull. The control surfaces consist of four elevators, two service rudders at the bottom, and two fins. The latter two are normally provided with means of locking rudder and fin together to form a fixed surface, or may be arranged as automatic rudders. All surfaces are mutually interchangeable by means of minor modifications. The elevators are limited to approximately 20 deg. movement,

and the lower rudder to 30 deg. each way, by means of stops in the car. All movable surfaces are counterbalanced. Each fin is externally braced by a pair of streamline wires.

The fin and control-surface frames are made of aluminum alloy and covered with corrugated Alclad of an average thickness of 0.008 in.

CONTROLS

The rudders as well as the elevators are operated by wheels. To move the elevators from extreme up to extreme down position requires two complete turns of the wheel. The extreme movement of the rudders requires three complete turns. The control cables are brought from the wheels in the forward end of the car beneath the floor to the rear end of the car in such a way that they are easily accessible for inspection. From an outside "pulley bridge" at the rear end of the car the elevator cables lead through Bowden casings to the elevators, while the rudder cables lead over pulleys at the leading edge of the fins direct to the rudders. The rudder cables from the two rudders are joined together just abaft the car and carried through to the control wheel as a single cable. At the point where they are joined an auxiliary hand line is attached which enables the controls to be operated in case of breakage of cables in the car. As the elevators and rudders on each side of the ship are operated independently (the independent elevator cables being carried right through to the control wheel), the breakage of the cables on one side still allows the ship to be controlled by the surfaces on the other side. The control cables throughout are $^1/_8$-in. diameter 7×19 extra flexible steel cable.

TABLE 3 GENERAL WEIGHT STATEMENT, "ZMC-2" AIRSHIP

	Pounds	Pounds
Hull		4,625
Frames	965	
Longitudinals	420	
Skin	2,700	
Seam rivets	30	
Seam dope	70	
Closing seam	30	
Ribs and diagonals	55	
Attachments	355	
Ballonets		780
Fin group		650
Car		1,310
Power plant		1,750
Total weight empty		9,115
Useful load		3,127
Crew	600	
Fuel	1,200	
Oil	200	
Ballast	420	
Cargo and passengers	707	
Gross lift with 92 per cent pure helium at 60 deg. fahr. and 29.92 in. Hg		12,242

CONSTRUCTION, ERECTION, AND ASSEMBLY OF THE "ZMC-2"[3]

The assembly and erection methods of the *ZMC-2* were given prime consideration even during the preliminary design of the ship. The building of rigid airships is not only a design problem but a construction problem of the first magnitude. It was not entirely necessary that the ship be constructed with the skin plating and the main seams running transversely; it could have been constructed with the plating and main seams running longitudinally.

The assembly of the metal plating into a gastight hull was accomplished very efficiently by building it in two halves, erecting each half with its major axis vertical to the floor, and then turning them up into a horizontal position and joining them together into a complete hull. The hull plating was built up on a series of transverse rings, each of which was the surface of a frustum of a cone. Each ring was composed of a number of equal panels, the panels being cut to the proper curvature from flat sheets and riveted together end to end to make up a curved band which became one of the transverse rings when riveted in place.

A manhole placed at the bow and stern of the hull was the starting point of each half. The first ring of plating was riveted to the manhole by hand and suspended by a single cable through the center of the manhole in such a manner that the manhole and ring were parallel to the floor. The suspension was by means of a winch at the hangar roof so that the height above floor could be easily adjusted.

The automatic riveting machine, described more fully below, was then set up on a carriage. The carriage was mounted on

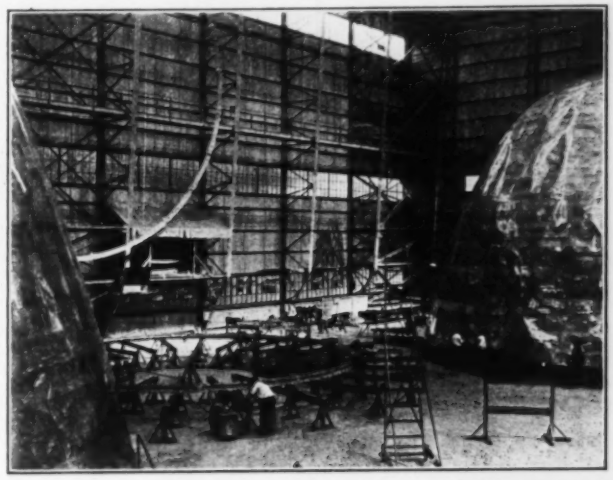

FIG. 7 ASSEMBLY OF MAIN FRAME MEMBER OF "ZMC-2"

concentric rails which were placed in the floor directly under each half of the hull. The riveting machine was then adjusted to the proper angle of the hull plating. The manhole with the first plating ring attached was then adjusted to the level of the riveting-machine jaws and the second plating ring was riveted to the first, thereby completing the first transverse seam in the hull plating. A gaging device was located on the riveting machine, giving a correct and uniform overlap of the plates. When the transverse seam was completed the two ends of the transverse band of plating were riveted by hand, thus closing the band into a complete ring.

The assembly was then raised by means of the winch, the angle of the riveting machine again adjusted, and the next transverse band was riveted to the last one in a like manner, the shape of the panels with the proper overlap determining the form of the hull.

As the riveted transverse seam emerged from the riveting machine it was inspected and repaired. Any defective rivets were drilled out and replaced with hand rivets. It should be noted that the defective and missed rivets amounted to only about one-third of one per cent of the total number used.

After a thorough check on the seam by an inspector it was given his approval and the sealing compound applied to the seams to make them gastight.

THE FRAME ASSEMBLY

As one band after another was added, the thin plating was supported by a light falsework of wood until it reached the point where the first transverse frame went in. This frame, having previously been assembled on the radial jig, was expanded

[3] Chapter in Appendix; prepared by Edward J. Hill and Arthur G. Schlosser, Detroit Aircraft Corporation, Detroit, Mich.

tightly into the plating and riveted in its proper place with respect to a given plating ring. After riveting in the transverse frame the longitudinal members connecting the frame to the manhole were forced tightly into the plating and riveted in place. The whole assembly of plating and internal structure was then given a thorough inspection.

The assembly of the plating then commenced again and proceeded down to the point where the next transverse frame was put in, and the longitudinal members connecting it to the previous frame were put in place as before.

Thus the assembly proceeded progressively from frame to frame, and as the maximum distance between frames was 18 ft., the work was always within 20 ft. of the floor and all the scaffolding required was ladders about 16 ft. high. All work on

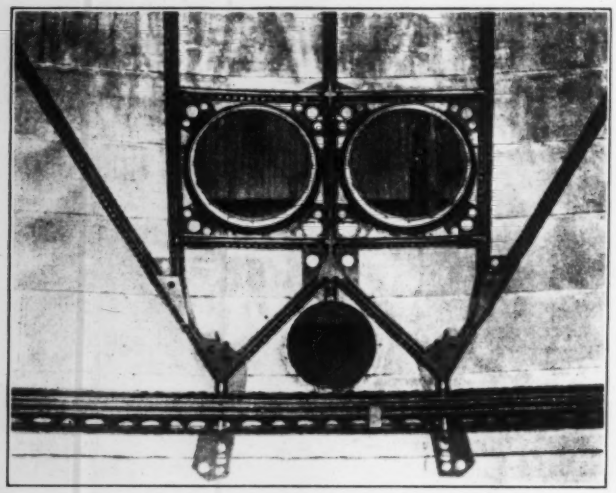

FIG. 8 REINFORCING AROUND VALVE SEATS IN HULL

the hull was completed and passed by the inspector while in range of these ladders.

While the structure was being placed in one of the halves, the skin plating was being assembled to the other and vice versa, causing the two operations to dovetail perfectly. There was very little lost time from having one crew wait until the other was out of the way.

As the weight of the assembled hull increased, the suspension was changed from one single cable at the center of the manhole to a bridle which distributed the load from the single cable to eight clips provided for the purpose on one of the main transverse frames. The hull was guyed from the sides of the hangar by cables to prevent it from swaying and turning. The operation of sewing the plating was continued, and main rings and longitudinals were put in place until all plating was riveted. Each half was then completed by the addition of a small angle riveted on with one leg inward.

JOINING THE HULL SECTIONS

The point at which the two halves were joined together was at the maximum section, 63 ft. from the bow and 86 ft. from the stern. Thus the stern section was 23 ft. longer than the bow section. While still in the vertical position the two sections were given a final inspection, and when passed were ready to be turned into the horizontal position for joining together.

The turning was accomplished by a system of equalizing bridles and winches. Two turning bridles were used for each section, one being attached at the lowest main transverse frame and the other at the highest. The bridles were attached to the frames at four points, and by running over pulleys they equalized the loads. They were then brought up to a single cable which wound on a winch mounted on a trolley on the monorail at the apex of the hangar roof.

By taking up on the bridle connected to the lowest frame, the lower end of the hull section was slowly raised and the upper end in a like manner slowly lowered. The weight of the section was gradually transferred from the original suspension bridles to the two turning bridles. A point occurred in this operation where the center of gravity of the section passed under the upper turning bridle and the total weight of the section was then supported entirely by four points on the one main frame. This was the critical point, and once passed, the lower end was raised and the upper end lowered until it was in a horizontal position.

When the two halves were in the horizontal position they were each suspended by means of the bridles at two of the main frames. The bridles were attached to cables which wound on the winches, which in turn were mounted on trolleys, so that each section could be raised, lowered, tilted, or moved back and forth along the trolley rail into any position—and by this means the two halves were brought together and lined up for the joining.

THE CLOSING SEAM

Before any riveting was done on the final joint, the plating was thoroughly clamped in position. It required many clampings and reclampings before a satisfactory job was obtained. In this clamping and subsequent riveting it was necessary for one workman to work inside and one outside at any point on the seam. To accomplish this an opening was cut in the bottom of the hull and an adjustable extension ladder put through this opening into the inside of the hull. From this it was possible to reach any point on the inside of the seam. For the outside riveting of the final seam a workman was suspended on a sling from the hangar roof over the top of the hull, and from a ladder on the sides and bottom.

When the two halves had been satisfactorily clamped together by the boundary angles the actual riveting of the joining seam began. A lap strip or metal band about two inches wide was laid over the joint and a double row of rivets joined this band to each of the two sections. This was entirely a hand-riveting job and the workmen were given every facility for speeding up the work, yet it took two men the equivalent of two months at eight hours a day to complete the seam, a job which the automatic riveting machine could have done in six hours. After riveting, the seam was sealed and the connecting longitudinal structural members riveted in place.

While the final seam was being riveted, the fins and rudders were bolted to the fittings, which extended out from the main frames designed for that purpose, and the control lines run down to the car through Bowden casings which were cemented to the outside of the hull plating.

THE INTERNAL STRUCTURE

The internal structure was built up entirely of rolled and flat-plate sections riveted together. The five main transverse frames are of the triangular type having a rolled channel member at each corner riveted to flat plates which make up the sides. The channel members were rolled to fit the circumference of the hull at that point, and the flat-plate sides were cut on the proper curvature to make a complete girder having the required curvature and angle of the hull.

Wooden formers were built for sections of each frame to the exact shape and curvature required, and into them were clamped the channels and plates making up the girders to be riveted together. When completely riveted, the sections rigidly maintained their shape and curvature. They were then taken out of the formers and assembled into a complete ring on the radial jig.

On the radial jig the sections were laid out into a true circle and leveled up. The joints connecting them into a complete ring were then riveted and the radial wiring put in place and adjusted while the frame was perfectly round. The wiring was removed before placing the frame in the hull, and later replaced and adjusted to the exact position it had been in while in the radial jig. This insured the frame's being round.

Longitudinal members were in all cases a single rolled channel section. Each one was rolled to fit a former representing the longitudinal curve of the hull plating. Flanged lightening holes were extensively used in the channel sections and side plates of the frames to lighten and strengthen the structure.

All the material in the internal structure was built of Aluminum Company of America's aluminum alloy 17ST. All the sections were rolled and worked in the hard state with one exception, namely, where the curvature was so great that heat treating was necessary. The rivet used to build up the structure was the same flat-head rivet that was used to rivet the plating to the structure, the sizes used being mostly $^3/_{32}$ in. in diameter. At joints and highly stressed places $^1/_8$-in.-diameter rivets were used, and in a few exceptional places $^3/_{16}$-in. rivets were found necessary.

Cutting the Plating Panels

The cutting of the plating panels was done very accurately as the hull was constructed by building from one ring of plating to the other, gaging from the edges of the plating in all cases. Naturally any errors in the cutting of the panels would accumulate. It should be remembered that the shape of the hull was entirely the result of the shape of the panels, and therefore that any errors would affect the hull to the extent that the internal structure would not fit.

The panels were cut to various radii, ranging from a few inches at the extreme bow and stern to over three miles at the maximum diameter. For scribing all radii under 20 ft. a specially constructed beam trammel was used. For larger radii recourse was had to an indirect method based on the geometric principle that the locus of all points, which joined to two fixed points form a constant angle, is a circle.

A metal-topped table was constructed with two fixed metal pins spaced 14 ft. apart. Two straight edges 14 ft. long were joined together with a pivoted point, adjustable to any angle. These straight edges were very heavy and were mounted on rolling balls to allow them to roll over the table top freely. With the straight edges rigidly clamped to a given angle, they were rolled across the table with each straight edge in sliding contact with one of the fixed pins. This caused the apex of the angle formed by the two straight edges to scribe the arc of a circle, and the length of the radius of each circle was easily controlled by setting the angle of the straight edges to the calculated angle.

The sheet to be scribed was clamped to the surface of the table, then the scribing point of the arc machine was brought down in contact with the sheet. The machine was then drawn from left to right by hand operation over the pins until a satisfactory pattern was scribed. The sheet was then removed from the table and trimmed around the scribe line, and the final panels were then made from this pattern.

The Gastight Sealing Compound

The development of the sealing compound was given much thought. A compound had to be found that would adhere to the metal and seal the seams perfectly, yet it had to be a substance that would remain flexible and pliable at winter temperatures and at the same time would not become fluid at the higher summer temperatures. A satisfactory bitumastic compound was finally arrived at. This was applied to the inside of the seams immediately after the riveting had been inspected and approved.

The first coat was thinned out with naphtha until it was very fluid, and was then flowed into the seam between the overlapped plates by means of a rubber-bulb syringe with a very fine nozzle. Capillary action caused the fluid to penetrate into the seam, and in this it was greatly aided by gravity as it was applied in such a manner that it always flowed downward into the seams. This thin application dried very quickly, due to the rapid evaporation of the naphtha, and as soon as shrinkage was apparent, more compound of the same consistency was applied.

In this way the seam was kept full of the fluid until every void was filled by the building up of the sealing compound as the naphtha evaporated. When the minute spaces between the overlapping plates were thus thoroughly filled and no more fluid could be made to flow into the seams, a heavy application of very thick compound was applied over the edge of the plate exposed on the inside of the hull.

This application was thinned by heating to about 200 deg. fahr. This was accomplished by means of an electrically heated pressure gun which forced the heated compound through a nozzle with an opening about $^1/_{16}$ in. in diameter. By this means a ridge of the compound was laid over the inner exposed edge of the plating, covering it completely. This compound cooled very rapidly in contact with the metal and thus did not fall from the seam of its own weight. While this application was still damp, it was dusted with aluminum powder to facilitate inspection and to harden the "tacky" surface.

The Automatic Riveting Machine

The development and perfection of the automatic riveting machine played a very important part in the construction of the metal hull. It would have been practically impossible to build the hull without such a machine. The machine riveted a very highly efficient seam composed of three rows of staggered rivets, the rows being $^3/_{32}$ in. on centers and the rivets being spaced $^1/_4$ in. in the rows, the overlap of the plating being $^7/_{16}$ in.

Aluminum-alloy wire 0.035 in. in diameter was fed into the riveting machine. The wire was cut to length and forced through the overlapping sheets into hardened steel dies, cutting a clean, round hole. The soft wire was able to punch a hole in the hard sheet because, being confined, it could not expand when the pressure was applied, but had to punch through the sheet. When the wire was through the sheet, it was headed first on the underside and then on the top, making a complete rivet. The machine then spaced the next set of rivets automatically.

Three rows of rivets were driven at a time and at the rate of 140 (or 1 ft. of seam) per min. while operating steadily. In actual operation the machine was able to rivet up to 200 ft. (or 28,800 rivets) in eight hours; the greatest number of rivets driven in eight hours was 40,000, not including time for set-up. Concentric circular tracks were laid on the floor, whose common center was at the axis of the hull assembly. A car mounted on these tracks carried the riveting machine around the hull. The riveting machine was mounted on the car by means of an arm with a universal movement and balanced by springs so that it could be easily moved to any position independently of the position of the car, within a limit of about two feet.

The riveting machine automatically pulled itself along the sheet by its own feeding mechanism. A ratchet mechanism conveniently placed for the operator's use was employed to propel the car around the hull. Inasmuch as the forward movement of the riveting machine and car was independent within certain limits, it was not necessary for these two operations to be synchronized.

Factors in the Design of Commercial Airplanes

By CHARLES TALBOT PORTER,[1] BRISTOL, PA.

A steady and profitable market may be expected for existing equipment in remote and inaccessible places, where other forms of transportation are not available, but the real problem is to make the air transport compete successfully with the extra-fare trains. The real commodity that is being sold is transportation, and the factors involved are speed, comfort, and cost, assuming of course that safety and reliability have been demonstrated. The combination of these three factors must equal that of the fast train. The cost of air travel is of necessity high; therefore the speed-comfort combination must exceed that of the railroads. In general, the comfort of the train at least equals that of the airplane, so the latter must be sold on the speed factor alone, without sacrifice of a certain minimum requirement for comfort and at a cost that is justified by the increase in speed.

Existing air transports have a high speed of 135 to 145 miles per hour, a capacity of ten to twelve passengers, and a power output of 100 hp. per passenger. The speed has been obtained by increasing the power per passenger to nearly double that formerly thought sufficient. High power means high fuel capacity and decrease in percentage of pay load.

The author advocates the development of a 30 to 40 passenger airplane that will equal present speed requirements with a reduction of power to 50 to 60 hp. per passenger. To obtain this result he advocates abandoning direct-drive air-cooled radial engines and replacing them by geared engines, air-cooled or liquid-cooled, placed preferably inside the wing, with a remote drive to the propellers. The airplane itself should approach the flying wing, the wing loading should be high, and the landing gear should be retractable. Due to increase in landing speed the brakes should be much larger, should be operated by mechanical power, and should be capable of utilizing the full friction between the wheels and ground. The material from which the airplane is made will depend largely on a depreciation factor which is not yet clearly defined and cannot be set up until large airplanes have been in operation for a longer period of time.

THE history of American aviation during the last ten years has been as romantic as it has been remarkable, and the men in charge of the technical development find themselves in a most extraordinary position. Plodding along during the lean years, between 1918 and 1927, when their sole support came from the military authorities, the technical leaders of the industry find themselves suddenly supported by great financial resources and told to go forth and earn returns on large sums of money. This situation has its difficulties as well as its elements of strength. Probably no industry in its infancy has been in a stronger financial position to take advantage of whatever development the future may hold in store, but at the same time there is every reason to believe that the financial structure is stronger than the technical foundation. Hence a heavy responsibility rests on the aeronautical engineers to justify the confidence of the public in their chosen profession. The time has come to take careful stock of the situation and to control the direction of development in order that the resultant product may fill a definite economic need and produce a profit for both manufacturer and user.

The title of this paper was chosen to limit the discussion to large airplanes used for transportation. The term commercial airplane has in the past referred to any airplane that was not solely military in character, and this fact is a tribute to the extent to which the industry has in the past depended on the military services. In future this term should carry the same significance that the term commercial automobile conveys, and should be limited to those airplanes that are used in supplying transportation or some other business commodity.

The large commercial airplane really supplies transportation and is of value only when the commodity thus supplied can be marketed at a lower price for service rendered than similar service offered by the older and more established methods. This leads to an examination of the factors entering into the service rendered and their relative importance. These factors are speed, cost, safety, and comfort—and, most important of all, existing competition. This latter factor sets the standard that must be met or bettered to make operation an economic possibility. The author has designed airplanes for operation over the Andes and in the Peruvian hinterland where the only competition was small river steamers, connecting with Indian dugouts and mule pack trains. Although the airplanes were single-engined open-cockpit machines with a cruising speed of 85 to 90 m.p.h., the service rendered was faster, cheaper, safer, and much more comfortable than anything the competitor could supply, and hence was bound to be a success. The same condition will apply where the competition is supplied by small vessels making infrequent sailings. In fact, a steadily increasing and profitable market for air transportation, using equipment as now developed, may be expected from the more remote and inaccessible portions of the world where quick and cheap boat and rail transportation has not yet been provided. However, this type of market will not supply the demand that the industry needs, and the aeronautical engineer must produce a product that can equal the speed, cost, and comfort combination of the extra-fare train, with its dining, sleeping, and club-car accommodations.

Unfortunately, these three factors are mutually antagonistic. At present the airplane cannot compete either in price or in comfort with the extra-fare train; hence, its only reason for being is speed. Therefore, this factor must be improved upon and given priority over every other consideration. Cost, however, increases very rapidly with speed and also with comfort and may become prohibitive if both these other factors are exaggerated. However, it is probably safer for the designer to assume that, if a fast and reasonably comfortable service is rendered, the public will pay the bill.

The hardest problem for the designer is to get the proper relation between comfort and speed, assuming that the cost factor remains constant. Obviously, the maximum speed can be obtained by crowding a given number of passengers into as small a space as possible and having them "stay put," without giving them the various little accessories that contribute to their enjoyment. However, the class of passengers that can afford the high cost of air transportation is one that can afford and will demand all the conveniences of life, and will look askance at a journey, no

[1] Keystone Aircraft Corporation. Mem. A.S.M.E.

Contributed by the Aeronautic Division for presentation at the Annual Meeting, New York, N. Y., December 2 to 6, 1929, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

NOTE: Statements and opinions advanced in papers are to be understood as the individual expressions of their authors, and not those of the Society.

matter how swift, if it embodies any real bodily discomfort. Therefore, there is a certain minimum of comfort, and hence size and weight, which must be supplied, and the designer must start with this requirement and at the same time maintain his high speed.

It is generally claimed by air-transport operators that a cruising speed of 110 to 125 m.p.h. is necessary for successful competition with railroads. The term cruising speed is elastic and depends upon the revolutions per minute of the engines at which the pilot chooses to operate; hence, it is better to set up a criterion based on maximum speed. This figure may be set for the present at 145 to 155 m.p.h.

Having set up a high speed that must be equaled or bettered, the designer thus turns his attention to the size of body that must be provided. This will depend on the length of journey, but in general it may be assumed that flights of three to four hours will be the shortest in duration for which airplane use is justified. Each passenger will want a comfortably upholstered seat at least 20 inches wide, which should be adjustable at will. At the same time, he will require a certain freedom of movement, such as is furnished by the railroad train. The relief afforded by getting up and walking around and, in general, changing location is so great that some eminent authorities believe that in future we shall have 40-passenger airplanes carrying a maximum of 20 people.

This requirement of mobility of action points to the development of large airplanes with a total capacity of 30 to 40 passengers. Several developments of airplanes of this type are now under way, and the author believes that this size probably represents the economic limit at the present time.

Before, however, going too far with the determination of the proper passenger capacity, considerable thought must be given to the relation between size and cost of operation per passenger mile. The direct cost of fuel, oil, salaries, maintenance, and overhead is easily obtainable, but the proper factor for depreciation, due to normal wear and tear, accident, and obsolescence, is not known with any degree of certainty and cannot be known until large transports have been in operation for some years. Obviously an airplane of large capacity can be operated at less cost per passenger mile than a small one, but when depreciation on capital cost is set up, will the resultant cost be a minimum for the very large airplane or for one of intermediate size? So important is this relatively unknown depreciation factor that it may control both the size of airplane and the materials of which it is made.

Let us look briefly at the large transports now in operation and take stock of the situation, and then play the dangerous game of endeavoring to predict the line along which future developments will follow.

The present type of big transport is almost standardized as a high wing monoplane, employing three air-cooled engines, one in the nose and two below the wing. This type has been a very logical development. Three engines are the minimum number on which satisfactory flight can be maintained with one engine out; hence, this number will probably remain the minimum for subdivision of power required. There is now, however, a campaign being launched to do away with the nose engine in order to reduce fuselage vibration. To accomplish this the designer either will place his three engines entirely above the wing, or he can raise his wing above the body and mount his engines in the leading edge, or he can revert to a biplane with underslung body and the engines between the wings. The more logical development will be the use of four engines in pairs of tandems, with corresponding increase in size of airplanes.

The present transports have a high speed of 135 to 145 m.p.h., with cruising speed about 110 m.p.h. This is probably a little low for transport requirements, but even this speed had been obtained only by the use of 100 hp. per passenger, a figure that the author believes is too high for the result obtained. The ratio of useful load to gross load that may reasonably be expected with high-powered ships is 33 to 40 per cent. Out of this must come the weight of fuel and oil, and of course the more power per passenger the more of the useful load will be absorbed by the weight of fuel. The old rule for passenger ships was 50 hp. per passenger. Modern ships have doubled the power, and for this increase have given more speed, more reliability (three engines), and more comfort. The present cabins have two rows of comfortable seats and sufficient aisle space to give a reasonable amount of comfort and freedom of motion, but there is need of additional space for rest rooms or smoking rooms. This latter room should be so located and ventilated that the smell of smoke will not annoy the other passengers, especially those on the verge of airsickness.

The wing loading of modern transports, 14 to 16 lb. per sq. ft., is all that can be used with the present Department of Commerce ruling of a landing speed of 60 m.p.h. This rule, the author believes, is open to very serious objection. In an admirable paper entitled, "The Economic Relationship of Speed and Weight in Air Transportation," Mr. E. P. Warner evolves a most interesting relationship between economical cruising speed and landing speed. His conclusions are that cruising speed should not exceed 1.8 times the landing speed and that the cost of transportation at any given speed decreases rapidly as the wing loading is increased. This of course substantiates Dr. Rohrbach's theories, expounded many years ago, that in high wing loading lies the solution of the very large airplane.

In reviewing existing airplanes from the standpoint of materials used, a great variation of thought is at once apparent. There has been much talk of the advantages of all-metal construction. This is as ridiculous as to talk of all-metal houses or all-metal rowboats as having some fundamental advantage over wood. In building houses, as in shipbuilding, there is some economic size limit where metal has universally superseded wood, and this also may apply to airplanes, but the engineer should select his materials for each case for the best combination of safety, durability, cost, and performance; and while wood generally has been abandoned for body construction for reasons of safety and cost, the case of wood for wing beam construction is still very strong, and in any new project the use of wood should be investigated before definite decision is made to use other materials.

Present transports have a variation in capital cost of from $4000 to $6000 per passenger. Present indications are that no very great reduction in these figures is likely as the size is increased. It is well established that the larger the airplane the greater the attention required to detail to keep the established pay-load ratio, and hence an increasing cost. The large ship must justify itself on its apparent reduced operation costs, apparent because of the unknown depreciation factor.

Two new transports with capacity of 18 passengers have been constructed and show great promise, although they have not yet been in service long enough to prove whether they can increase the economy of operation. One of them designed under the author's direction is a high wing, externally braced monoplane of 16,000 lb. gross weight, using three 525-hp. radial air-cooled engines. The wing loading is 17 lb. per sq. ft. This ship has an excellent performance with a power loading of 87 hp. per passenger, and this should be a strong candidate for supremacy in the intermediate field. The other development is a remarkable piece of engineering work. The ship is a large biplane lightly loaded and using two 620-hp. geared water-cooled engines, which give a horsepower per passenger of 67. In fact, this airplane, compared with the older types, gives an equal performance with the same power and an increase in pay load of 50 per cent. It is open to the objection which may be applied to all twin-motored ships, that with one engine dead a satisfactory performance on the

remaining engine at altitude is difficult, if not impossible, and also the objection that the lower wing impairs the vision of the passengers, but otherwise the airplane marks a real advance in aeronautical design. One significant feature is the entrance of the liquid-cooled engine into the large transport field. This point is one of great interest and may mark a turning point in our ideas of engine-propeller efficiency.

Looking ahead, the author believes in the development of the 40-passenger airplane, but believes that present efficiencies must be improved and high performance obtained with an expenditure of 50 to 60 hp. per passenger. The first and most obvious step is to "clean up" the airplane and to increase the present propulsive efficiencies of the power plants. Present practice of stringing a number of direct-drive radial engines along the wing must be abandoned, or else the cowling must be much improved. The use of geared radials in this country has been very slow, but this change is a partial remedy at best. If the engines are to be hung in the relative wind, it would seem natural to expect the use of in-line air-cooled or the water-cooled type with Prestone cooling. The most elegant solution of the engine problem is to house all the power plants in the wing itself and to have them geared in groups to shafts which have large propellers located at some distance from the engine room. The similarity to marine practice is evident. While the development of clutches, gearing, and shafting of light weight will present quite a problem, the advantages are sufficient to make this a most promising direction for development.

Next in line will come the increase in landing speed, and at the same time the development of very effective power-operated brakes. The pilot should have at his control sufficient braking force to develop the full friction between wheels and ground at all times. This braking force with improved long-stroke landing gears and possibly a spoiler system to kill the lift of the wing should make landing at 80 m.p.h. a safe operation on any prepared landing field. The probability of forced landings should be greatly reduced by multiplicity of power plants.

Another line of endeavor should be the working out of a satisfactory retractable landing gear on large airplanes. The resistance of this unit is out of all proportion to its size and weight, and it is time it was removed from the relative wind.

Space requirements for rest rooms and sleeping accommodations seem to indicate the building of bodies with larger cross-section area, and this points to that dream of the airplane designer, the flying wing with everything inside except the propellers. This type of design, or a modification of it that improves the visibility of both pilots and passengers, seems to be a goal toward which to aim and would seem to offer the best speed-comfort combination.

A word should be said about large flying boats. The problem here is rather different. The competition moves at slower speed, and hence a reduction in top speed may be allowed without losing relative advantage as compared with the land transport. This is fortunate, as the flying boat may have to land in the open sea, and hence a lower limit on landing speed is advisable. This idea is contrary to modern European practice, where the highest wing loadings have been used on flying boats, but to the author the probability of landing a large boat in the open sea seems much greater than the necessity of putting an airplane down on an unprepared field.

After landing in rough water a flying boat should have reasonable seaworthiness and have a strong wing-tip float anchorage. This makes a strong argument for the biplane, where large area and rugged construction can be obtained for less weight than in the corresponding monoplane.

To summarize the foregoing remarks, the airplane designer, to be successful in competition with the extra-fare trains, must supply a combination of speed and comfort that will be sufficiently more appealing to the general public to justify the higher cost of air transport. In spite of the phenomenal advances of the last two years, air transport is not yet sold to the people at large. With increase in number of landing fields and improvement in the efficiency of the airplanes, there is no doubt that this scale will be consummated and that air transportation will play a prominent part in the economic life of the country.

Canadian National Oil-Electric Locomotive No. 9000

THIS locomotive is still being run in a semi-experimental way, and it is claimed that tests show a material reduction in the cost of operation. The locomotive is geared for high-speed passenger service and can make 70 m.p.h. with an output of 2600 hp. The tractive effort during periods of acceleration is 100,000 lb., and it can exert a tractive effort of 42,000 lb. continuously.

Adding to its abilities in regard to speed is its saving in time due to rapid acceleration. While a steam locomotive requires, say, a mile and a half in which to come to a stop from high speed and then to accelerate to high speed again, No. 9000 can do the same thing in considerably less than a mile. A comparison of overall lengths and weights shows that while a No. 6100 steam locomotive is 93 ft. $4^3/_4$ in. long overall, No. 9000 is 94 ft. 1 in. long overall. A No. 6100 steam locomotive, with tender, weighs 334 tons; No. 9000 complete weighs 303 tons. The pulling power of both types is about the same.

The locomotive was built and assembled at the company's shops at Kingston, Ont., while the motive-power units were made by Wm. Beardmore & Co., Ltd., in Glasgow, Scotland.

Each unit contains a 12-cylinder oil engine of the solid-injection type, 12 in. bore and 12 in. stroke. The nominal rating of the engine is 1330 hp. at 800 r.p.m. The engine is of the variable-speed type, and may be run at any speed between idling at 300 r.p.m. and full speed at 800 r.p.m., the engine governor controlling the throttle to maintain the speed corresponding to the governor setting. The engine develops its rated horsepower at a fuel rate of 0.32 lb. per b.hp-hr. It is started from standstill by power taken from a storage battery on the locomotive, using the main generator to crank it over.

The oil engine is water-cooled, with radiators of the honeycomb type mounted on the locomotive roof.

The exhaust gases of the oil engine are conducted to an economizer boiler in the cab and finally discharged to the atmosphere at a reduced temperature. The economizer boiler also serves as an effective silencer in muffling the exhaust of the engine. The heat saving in the exhaust gas is sufficient to heat a passenger train of the average number of cars for outside temperatures as low as 12 deg. fahr. below zero, with the oil engines operating at average loads, and for lower temperatures with the oil engines operating at full load.

An oil-fired boiler has been installed in each unit, which will operate, in conjunction with the economizer boiler, to supply steam for train heating during periods when the output of the latter does not meet this requirement.

The electrical equipment was designed by the Westinghouse Electric & Manufacturing Co. of East Pittsburgh. The system of control provides for varying the speed of the oil engine and generator voltage, and shunting the field of the series production motors for changing the speed of the locomotive. A torque governor automatically prevents overloading of the oil engine.—*Canadian Railway and Marine World*, no. 379, Sept., 1929, pp. 549–553, illustr.

Elastic and Inelastic Behavior in Spring Materials

Progress Report No. 5 of the A.S.M.E. Special Research Committee on Mechanical Springs (Technological)

By M. F. SAYRE,[1] SCHENECTADY, N. Y.

SINCE the Fourth Progress Report of the committee was published, work has been continued at Union College on fundamental studies of the elastic behavior of spring materials. The purpose of this work has been to lay a sound theoretical basis for the whole problem of spring design, taking up those underlying problems which it would be uneconomical for any one manufacturer by himself to tackle, but which are vitally necessary to a real understanding of the whole problem. During the past six months it has been possible to clarify several points which were uncertain at the time the last report was written, and to open up several new points regarding the elastic behavior of spring metals in tension. These results may prove to be of value outside as well as within the field of spring design.

1 In particular it is felt that the results very definitely confirm that the modulus of elasticity of a metal is not an absolutely fixed quantity. Overloading in tension beyond the yield point lowers the modulus of elasticity with respect to future lighter loads. Within limits, the greater the permanent elongation, the greater the reduction in modulus. Two weeks' rest at room temperature causes only a slight recovery. Specimens are being held for future tests at longer intervals. Such overloading as this, as in surging a spring, operates in two ways to increase the energy-storing capacity of a spring: first, by lowering the modulus of elasticity, and second, by raising the apparent elastic limit of the material. Further tests are desirable in order to show to what extent this gain is counterbalanced in other ways.

2 For years Hooke's law, that stress is proportional to strain, has been almost a fixture in engineering practice. Numerical results obtained seem to indicate a second-order correction to this law, not great enough to be perceptible for materials commonly used at low stresses, such as structural steels, but great enough to be noticeable at customary spring stresses in phosphor bronze and spring steel. With sufficiently accurate measuring instruments the stress-strain line appears to be continuously curved from zero load upward, not because of minute departures from elastic behavior, but because the elastic line itself is curved. The modulus of elasticity in tension decreases as the load increases, the decrease in slope of the stress-strain line being of the general order of magnitude of two to four per cent. This effect was noted in last year's work, but an attempt was made to fit successive straight lines to the stress-strain curve, so obtaining an upper and a lower proportional limit and two different moduli of elasticity. The work done since then has emphasized this curvature as a real elastic property and indicated that the proportional limit properly so called is not evidence of the elastic limit of the material, but tests have not yet been made on enough specimens to show whether the rate of curvature will vary with individual specimens, and whether such variation, if any, is indicative of the character of the material.

From theoretical reasons it is expected that in compression the modulus will increase as the load increases. Work is planned on the much more difficult problem of checking this phase of the work.

The practical effect of this curvature of the stress-strain line upon the stresses in a power or cantilever spring will be to shift the neutral axis toward the compression side, to slightly decrease the maximum stresses on the tension side, and to increase them on the compression side. The magnitude of the effect will be small.

3 In last year's report, mention was made of a discrepancy in the law of variation of internal friction, or elastic hysteresis, between tension and bending specimens. Later tests have shown that this discrepancy resulted from a sharp break in the law of hysteresis in tension which occurs at about the yield point. The precision with which it was possible to work last year was such that practically all our significant results in tension were limited to the upper load ranges, near or above the break in the curve. By multiplying the precision of the extensometer by five, so that one scale division of the extensometer now represents one part elongation in 500,000, and working with an extensometer with almost negligible instrumental hysteresis, it has been possible to obtain results on the lower part of the curve as well. For stresses below 160,000 lb. per sq. in., the actual width of the hysteresis loop (i.e., the amount of "backlash" which was shown by the specimen on descending loads as compared to ascending loads, at half full load) increased in these tests as some power of the maximum load varying between 2.5 and 3. The energy loss in hysteresis would vary as the maximum load raised to the 3.5 or 4th power. Above 160,000 lb. per sq. in., which is a point about midway between the elastic limit and yield point and not far from where appreciable permanent set first begins, and up to maximum stresses of 180,000 lb. per sq. in., the hysteresis varies more nearly as the eighteenth power of the maximum stress. In specimens in bending, the outside fibers reach the yield point only one by one as the load is increased, and consequently no such sharp change in the law of hysteresis will be evident.

4 Any overloading, to stresses which exceed this same figure of 160,000 lb. per sq. in., acts to increase the future energy loss in hysteresis, even for small load ranges. Within limits, the greater the amount of overloading, the greater will be the effect on the hysteresis. Recovery from the effect of the overloading, after two weeks at room temperature, was relatively slight. Further tests are planned to study the amount of recovery after longer periods.

The fact that permanent or quasi-permanent changes in both modulus of elasticity and hysteresis begin at about the same unit stress indicates that the two are tied together.

5 The data obtained as to the actual shape and character of the hysteresis loop are not yet complete. This information is of course likely to be of academic rather than of practical interest to spring manufacturers and users, but a number of questions have been asked about it. It seems to be more nearly of string-bean shape than like an ellipse, with pointed, eccentric ends, and with often a slight in-curve on the under side. The exact shape

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will depend upon the magnitude of the stress range, upon the speed with which the readings are taken, and upon how nearly the material has reached a cyclical state.

As stated in the preceding report, the experimental problems have not been entirely simple. The elastic changes in shape of a metal, particularly in tension or compression, are themselves small. Much of the work done has required the measurements of slight discrepancies in this elastic behavior of the order of magnitude of 0.00001 in., so calling for the highest available degree of precision, with repetition of work to allow for elimination of erratic results and for use of average values. It has been necessary to work in all cases practically to the limit of accuracy of the instruments used, and to apply all practicable precautions.

DETAILS OF WORK

The testing machine used was an Amsler universal machine with 50,000 lb. maximum capacity, but with seven load ranges. This was a new machine just installed by the college, calibrated in Switzerland and again calibrated here, up to a load of 4000 lb., using standard 50-lb. weights. It was installed in a large ground-floor room, practically free from vibration. The temperature at the machine was relatively uniform during the entire period of the tests with a maximum range from 68 to 78 deg. fahr. The range during any one day did not exceed 4 deg., and was usually not

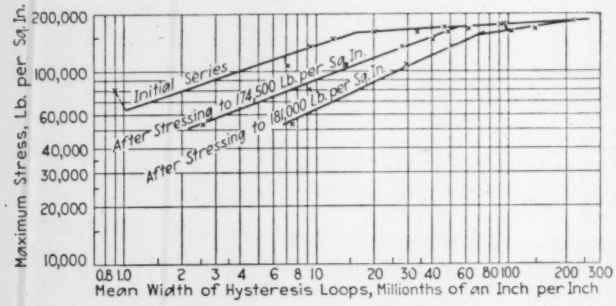

FIG. 1 MEAN WIDTH OF LOOP FOR HYSTERESIS IN TENSION
(Bars Nos. 17, 22, and 28, heat-treated flat steel wire.)

over 1 deg. A cloth curtain around the specimen and extensometer shielded them from direct drafts.

The extensometer used was of the Riehlé-Sayre type, developed by the author. For this work it was adjusted for an 8-in. gage length. Each of the 500 divisions on the scale represented an elongation of 1 part in 500,000, so that the full scale range represents 1 part in 1000, or a load range (for steel specimens) of 28,000 to 30,000 lb. per sq. in. Errors in absolute calibration of the extensometer are believed to be within 0.5 per cent. The extensometer is relatively free from instrumental hysteresis. The combined sensitivity of the testing machine and extensometer was such that successive readings, taken at the same nominal load reading (about 5000 lb.) on the machine checked within one division of the extensometer, equivalent to about 3 lb. load on the specimen. This, of course, was true only provided the load variation on the machine was kept small enough so that the internal hysteresis of the specimen itself was not a factor.

The method of operation was so planned as to eliminate experimental errors as far as possible. The accuracy of the hysteresis figures depended upon the sensitiveness only, and not upon the absolute accuracy of the testing machine and extensometer, since they came as a difference of two readings taken at the same load and at nearly the same point on the extensometer scale. Values of modulus of elasticity were based on sets of readings, each taken over practically full scale range of the extensometer. As a result, any errors of calibration of the extensometer as a whole or in individual parts of the scale affected only the absolute value of the modulus of elasticity and did not appreciably affect the difference in readings, upon which the conclusions are based. Any index error in the zero setting of the testing machine would not appreciably affect the conclusions. A consistent error in the testing machine, of the same percentage at all loads, would affect the absolute values of the modulus but not appreciably the differences in modulus. Erratic errors, varying in magnitude from point to point, remain as a possible source of error.

Most of the work was done on samples of the same $^1/_2$-in. × $^1/_8$-in. oil-tempered 0.68 per cent carbon flat steel wire used for the work of the last report. This metal was fully described in

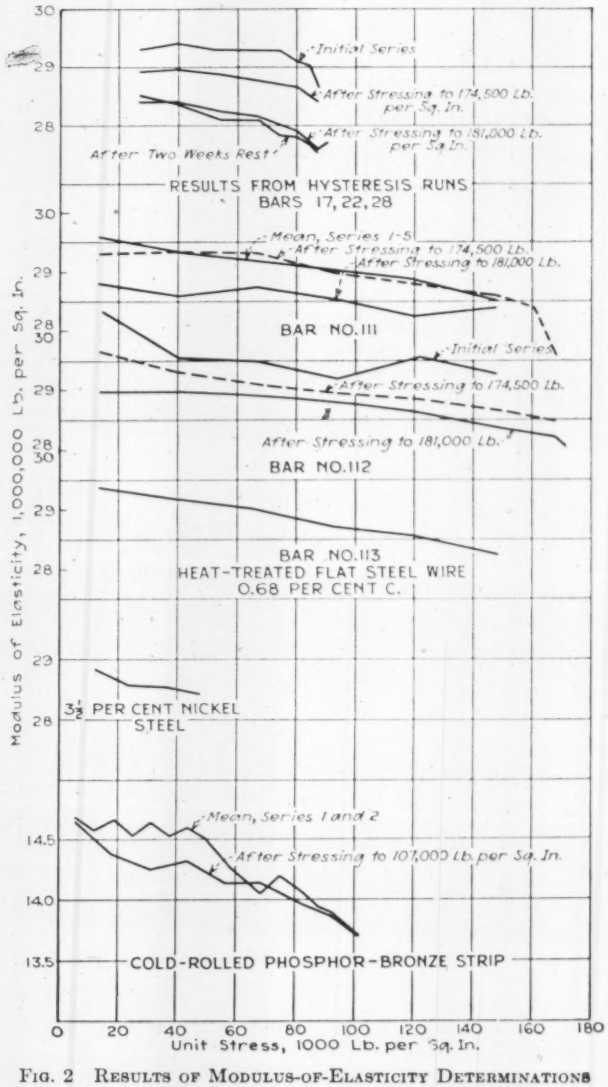

FIG. 2 RESULTS OF MODULUS-OF-ELASTICITY DETERMINATIONS

that report. It has a yield point of about 175,000 lb. per sq. in. and an ultimate strength of 198,000 lb. per sq. in. Tests were also made on flat spring-tempered sheet and round rod of phosphor bronze, and on a bar of nickel steel, both obtained locally.

In studying hysteresis the specimen was put through a series of cycles of loading and unloading between a nominal load and the desired maximum load in tension. After the specimen had approached a cyclical state, sets of readings were taken with the extensometer for three complete cycles, or more if necessary to obtain consistent values.

(*Continued on page 970*)

The Economics of Water Versus Steam Power

By GEO. A. ORROK,[1] NEW YORK, N. Y.

THE power resources of the world are quite large, but with varying degrees of permanency. We may say we have natural gas and oil for fifty years, coal for two thousand years, oil shales and peat for perhaps twice as many years; and then we have water power which may perhaps last till the close of the present geologic era, many thousand years ahead. This may not be true since most of our deserts—Sahara, the Gobi, the Interior Basin, Arabia, and Mesopatamia—were all once well watered, while the desiccation today is by no means complete. Power from water as compared with that from oil or coal may thus be termed inexhaustible. The only criterion of its economic value is the answer to the question, Can it be sold at a profit?

The Development of Power Generation

The economics of water versus steam power then becomes a question of the costs of power production and distribution from both sources at the market where the power can be used, and we shall deal only with steam power generated from coal, considering that the 2000 or more years of supply are, for the purposes of this paper, as inexhaustible as the sources of water power. We shall also assume electric generation and transmission, since in this way alone can the product of most water-power plants be brought to a profitable market. Two centuries ago we used overshot wheels and transmitted the power to a maximum distance of about 100 feet. A century ago we built canals at various levels, distributing the water instead of the power, and the maximum distance did not exceed four to five miles. In 1870 we used the water wheels to drive air compressors and distributed the power by compressed air through pipes to distances of 20 to 25 miles. But by 1891 we were transmitting electric power, water-generated, over a wire to distances over 100 miles. Today we have transmission lines between 200 and 300 miles long carrying large amounts of power without serious loss. Our major systems of electrical supply are linked up with ties and so interconnected that on one occasion a year ago the entire eastern portion of the United States from Boston, Mass., through Chicago, to Pensacola, Florida, was connected up, synchronized, and run as a single system for about thirty minutes.

Evaluation of the Cost of Water Power

The cost of the water-power plant will include the cost of the real estate and water rights, the cost of plant construction, the dam, head and tail races, penstocks, surge tanks, the turbines, generators, governors, and switchboard, and the cost of the transmission lines, transformers, and substations to the market. The cost of water power will include interest, depreciation, taxes, and insurance on the above plant cost plus the operation cost of the power plant, transmission line, and substations. Hydraulic plants are generally of concrete and massive in construction; the machinery is heavy, slow moving compared with steam machinery, and of high efficiency and long life. Transmission lines are now substantial constructions in steel and concrete. Real estate, water rights, and transmission-line rights of way vary from next to nothing upward, and only a promoter would estimate the cost of a hydraulic installation without extensive investigation and surveys. The cheapest hydraulic plant in the author's knowledge cost about $60 per kw. without transmission, the most expensive about $425 per kw. Many investigated sites figure higher than $600 per kw. Transmission lines may cost as low as $7000 per mile or as high as $100,000. From this widespread field it is evident that any calculation to be of general value must be put in such a form that we may enter with two or more variables to find the answer, the cost of power per kilowatt-hour delivered at the market. One of these variables must of necessity be the load factor; a second will be the sum of the fixed and operating

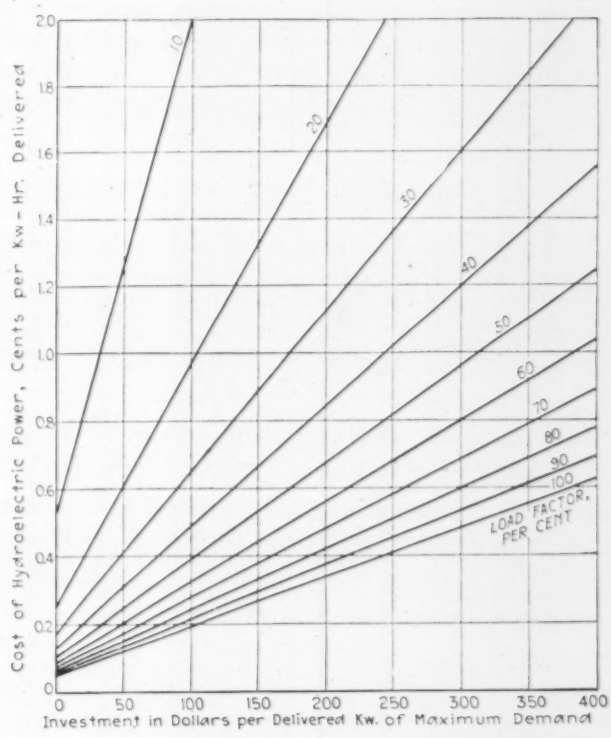

FIG. 1 COST OF HYDROELECTRIC POWER PER KILOWATT-HOUR DELIVERED FOR VARIOUS VALUES OF INVESTMENT PER DELIVERED KILOWATT OF MAXIMUM DEMAND AND FOR VARIOUS LOAD FACTORS

costs per delivered kilowatt of demand, or, better yet, the actual prime cost per delivered kilowatt of demand. Such diagrams are easy to construct when the facts are known. Fixed charges, including taxes and insurance, may run from 9 to 15 per cent. Taxes alone amount on some installations to 4 per cent, but in general 12½ per cent is a fair value to use for fixed charges. From the average of many cases it has been found that the operating costs amount to about $2.60 per kw. per year, while the transmission operating charge, including the substation at the receiving end, may be taken as $2 per delivered kilowatt of demand per year. One more factor is needed, the loss factor, or the ratio between delivered kilowatts and installed kilowatts. Fig. 1 shows such a diagram which has been used somewhat widely in the United States in various forms. In this figure the abscissas represent the investment in dollars per delivered kilowatt of demand, and the ordinates the cost of a kilowatt-hour in cents, to which the profit must be added if a price is required.

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Presented at the World Engineering Congress, Tokyo, Japan, October 29 to November 22, 1929.

DETERMINING THE COST OF STEAM POWER

When we come to evaluate the cost of steam power, a different set of conditions is encountered. In most cases the steam-generating station is located as close to the center of distribution as possible, having due regard to the location of condensing water and ready access by rail or boat to the coal supply. The condensing-water supply is most important since from 600 to 1200 tons of water are used in temperate climates per ton of average coal burned. Cooling towers can be used and a station may thus be located away from a water supply, but in such cases the loss in thermal economy is serious and only a very low coal cost or very high freight rate will justify such a location.

The cost of steam stations varies widely due to market and labor conditions, goodness of design, and to some extent to the steam pressure and expected thermal economy. The author has records of the costs of many central stations built since 1890, the lowest cost on record being about $50 per kw. of capacity, while others earlier and later have cost over $250 per kw. of capacity. The average cost, leaving out interest during construction, has been around $100 per kw. Averaging in ten-year periods, the cost in each decade has been very close to the same figure. European costs apparently run from 20 to 30 per cent lower, but an examination of the details will usually show that the saving is almost entirely due to lower building cost, the prices charged for equipment being only a little below what they are in America. We may then accept the $100 per kw. average cost as being probably both reasonable and sufficiently stationary.

Fixed charges could probably be figured at 12½ per cent, even with the 4 per cent taxes, were it not for the chances of supersession which upset any system of depreciation or reserves for renewals, and the author has taken fixed charges on the steam plant at 15 per cent or $15 per kw. per year. Labor, maintenance, oil, waste, and supplies, roughly proportional to output, may be taken as constant at 0.15 cent per kw-hr. The remaining factor in the cost of steam power is the coal, which may amount to 80 per cent or more of the operating cost, or perhaps with cheap coal run very much lower. Table 1 shows the method of calculating steam costs, which, for the various load factors and with coal varying in price by $1 intervals, are plotted in Fig. 2. In this figure the abscissas are load factors while the ordinates as before are costs of delivered kilowatt-hours in cents. The 20 per cent steam reserve sanctioned by good practice is included in the costs.

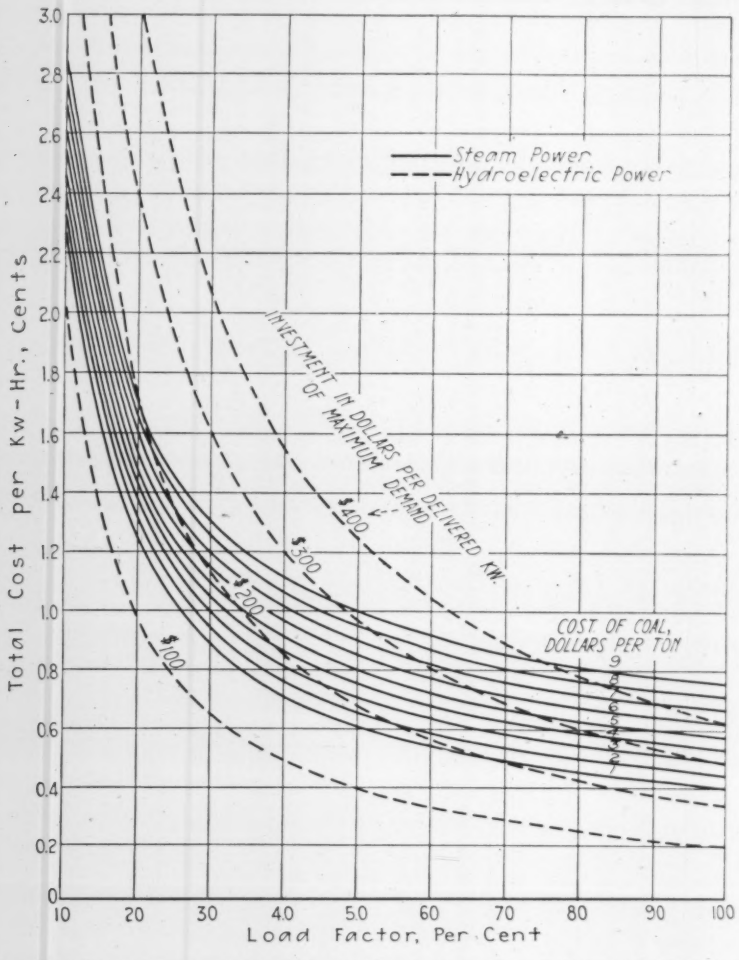

FIG. 2 COMPARISON OF TOTAL COSTS OF STEAM AND HYDROELECTRIC POWER PER KILOWATT-HOUR

COMPARATIVE TOTAL COSTS OF STEAM AND HYDROELECTRIC POWER

On this same diagram the cost of hydroelectric power with various investments per delivered kilowatt of demand may be plotted. Though the shapes of the curves are somewhat similar, the diagram readily shows what values of fuel, load factor, and investment will yield power at equal cost.

It is much better to plot these values on logarithmic paper, giving a more open diagram. On this type the hydraulic entries are straight lines and it is much easier to interpolate for any investment value. Fig. 3 shows this logarithmic plot, and from it we may read that for a 50 per cent load-factor load with $5 coal we can afford to pay about $240 per delivered kilowatt of demand for the water-power installation with its transmission lines, or $100 for a steam station with a 20 per cent reserve installation. Or if we are considering a water power on which the investment would be $200 per delivered kilowatt of demand at 40 per cent load factor, we could substitute for it a steam

TABLE 1 COST OF GENERATING STEAM POWER

[5 units (one in reserve). Cost of plant complete per kw. = $100. Fixed charges = 15 per cent. Yearly fixed charges = 1.2 × 15 = $18. B.t.u. per kw-hr. = 13,000 + (100,000/L.F.). Lb. coal (14,000 B.t.u.) per kw-hr. = 0.929 + (7.15/L. F.)]

	Load factor, per cent						
	100	80	60	40	30	20	10
Hours utilization per annum	8760	7008	5256	3504	2628	1752	876
Fixed charges per kw-hr., cents	0.205	0.257	0.342	0.514	0.685	1.028	2.054
Other charges per kw-hr., cents	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total charges per kw-hr., cents	0.355	0.407	0.492	0.664	0.835	1.178	2.204
Coal, lb. per kw-hr.	1.000	1.018	1.048	1.108	1.167	1.287	1.644
Total cost, cents per kw-hr.:							
Coal at $1 per ton[1]	0.400	0.453	0.539	0.714	0.887	1.236	2.277
Coal at $2 per ton[1]	0.444	0.498	0.586	0.763	0.939	1.293	2.351
Coal at $3 per ton[1]	0.489	0.543	0.632	0.812	0.991	1.350	2.424
Coal at $4 per ton[1]	0.542	0.597	0.688	0.871	1.053	1.418	2.512
Coal at $5 per ton[1]	0.578	0.635	0.726	0.912	1.095	1.465	2.571
Coal at $6 per ton[1]	0.623	0.680	0.773	0.961	1.148	1.523	2.644
Coal at $7 per ton[1]	0.668	0.725	0.820	1.010	1.200	1.580	2.718
Coal at $8 per ton[1]	0.712	0.771	0.866	1.060	1.252	1.637	2.731
Coal at $9 per ton[1]	0.757	0.816	0.913	1.109	1.303	1.695	2.865

[1] 2240 lb.

station representing an investment of half as much if we could purchase coal at $3.50 per long ton, the cost of service remaining the same. Fixed charges on the water-power plant would be 85 per cent of the total cost, and only 60 per cent for the steam plant.

LIMITATIONS TO WHICH HYDROELECTRIC PLANTS ARE SUBJECT

But this does not tell the whole story. Run-of-stream plants can only deliver power up to the low-water flow of the stream. If 12-hour pondage can be obtained, then twice the low flow is obtainable for 12 hours, and with 24-hour pondage the day flow may be discharged in a short time at a high rate. When storage may be built in addition to pondage, many combinations are possible. Complete storage is rarely found, and indeed is rarely necessary. In streams having a variation of 1 to 300 between low- and high-water flow a storage equivalent to one-fifth the run-off with a small pond has shown a utilization of over 80 per cent of the flow—but the rainfall was well distributed. Compare a stream of this variation with the Niagara River, whose variation is 1 to 1.3, where the use of water is limited to a small portion of the flow. It would be easy to obtain 100 per cent utilization of the available water if a steady load of that magnitude could be secured, but even here an 85 to 87 per cent utilization is about the best that can be done. In most cases a steam auxiliary is necessary, even where both pondage and good storage are found. The variation in kilowatt-hours produced by a hydro plant in wet and dry years is often as large as 50 per cent, and factors of this sort must be introduced suitable to the stream characteristic.

Steam plants, on the contrary, need no such discriminating analysis. Their only serious variation lies in the coal price, which may vary due to market conditions and interruptions of production and transportation, and the introduction of newer types of machinery, i.e., obsolescence. Most large steam installations obtain their coal from as many sources as convenient in order to insure continuity of supply. Obsolescence cannot be guarded against and must be accepted when it occurs. It may be said that, given a market of a certain type, steam-plant costs show smaller variation than water-plant costs. A dry year may increase the kilowatt-hour cost of water-generated current 100 per cent, while a 100 per cent increase of coal cost, the only real variable with steam-generated power, would add at best only 30 per cent to the cost of current. This has been shown in detail by Markwart in the *Journal of the Franklin Institute*, August, 1927.

SELF-SUFFICIENCY OF STEAM PLANTS

Steam plants are self-sufficient. There are many systems, operating without hydroelectric auxiliaries, giving continuous electric service at reasonable cost. Hydroelectric auxiliaries may cheapen the cost, but cannot improve the service. Hydroelectric systems, however, are not usually sufficient in themselves and must use an auxiliary steam supply for four reasons:

1 To give best system economy

2 For stand-by purposes (failure of transmission)

3 For meeting the seasonal water deficiency during the low-water period on non-regulated streams

4 For meeting the dry-year water deficiency.

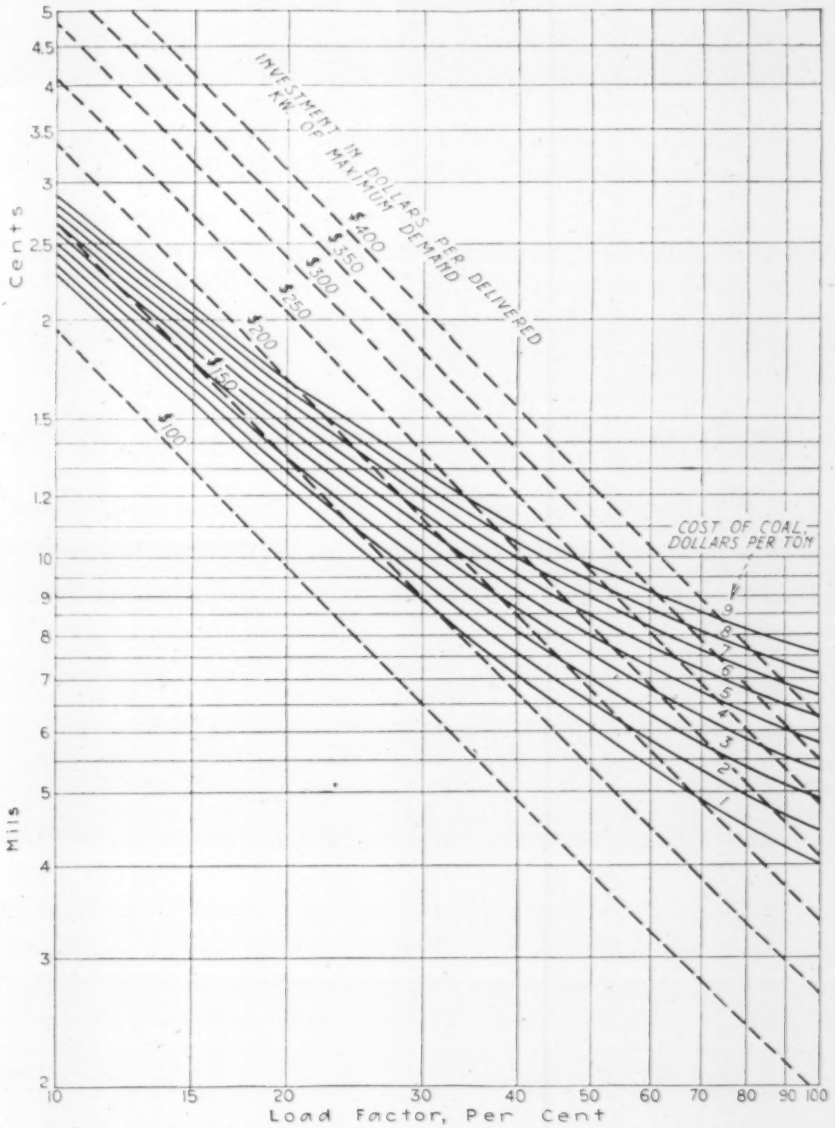

FIG. 3 COMPARISON OF TOTAL COSTS OF STEAM AND HYDROELECTRIC POWER PER KILOWATT-HOUR (LOGARITHMIC PLOTTING OF VALUES GIVEN IN FIG. 2)

Even such aggregations as the Niagara system have a steam reserve to take peaks and meet emergencies, as well as connections to other water- and fuel-power companies through which power may be obtained. The large hydro systems of the Southern California Edison Company, the Southeastern Power and Light Company, and the Pacific Gas and Electric Company, each generating over 2,000,000,000 kw-hr. per year, have a one-third or larger steam auxiliary as well as interconnections with other companies. If this necessity arises in such a perfectly regulated water power as Niagara where the flow only varies between 200,000 and 250,000 ft. per sec. and the allowable

draft is around 56,000 ft. per sec., the necessity, in a fully regulated smaller stream utilizing 90 to 95 per cent of the stream flow at all times, which may vary between dry and wet years from 40,000,000 kw-hr. to 80,000,000 kw-hr. per year, is much more cogent. The hydroelectric company is faced with the necessity of restricting its sales to the dry-year output, or it must purchase or generate by fuel sufficient kilowatts and kilowatt-hours to meet peaks and yearly outputs. And thus the steam reserve has been built up in practically every water-power system. Introduced at first to carry short peaks or to bridge over a cessation of service due to transmission-line failures, the steam auxiliary has been extended to meet output requirements in the dry seasons and during years of low rainfall. Then as the output and demand have increased, more and more of the output has been carried on fuel, until finally, no more water being available, the fuel plant may carry the bulk of the load, while the hydro takes a subordinate position. If pondage happens to be available, the hydro becomes a peak and stand-by proposition, generating its entire output as daily peaks and being used for only a few hours each day. Even with storage to regulate the stream to nearly uniform flow, given sufficient pondage the peak use of hydro may be economical.

Hydroelectric Power a Constantly Diminishing Percentage of the Total Power Generated

But there is another limit to the use of water power not included in the economic reasons which have been stated. It is easy to show that if all the rain falling on the United States were utilized as power between the level at which it fell and the sea level, the power developed, if generated by steam at 2 lb. of coal per kw-hr. and at 100 per cent mechanical efficiency would represent a coal consumption exceeding the present national coal production by about 10 per cent. Evaporation and growing vegetation necessarily reduce this total by about one-half. Long, nearly flat slopes and subterranean flows account for perhaps 30 per cent more, and the U. S. Geological Survey estimates a maximum possible output as around 160,000,000,000 kw-hr., about a 20 per cent utilization of the total rainfall. The actual survey figures are:

20,700,000 kw. 90 per cent of the time = 163,000,000,000 kw-hr.

or

32,800,000 kw. 50 per cent of the time = 144,000,000,000 kw-hr.

We actually have a trifle over 9,000,000 kw. of hydro power installed which should yield somewhere between 71,000,000,000 kw-hr. and 40,000,000,000 kw-hr. On this installation we actually generated 34,000,000,000 kw-hr. in 1928. On the same ratio, when all possible plants are built irrespective of cost, we may expect roughly 120,000,000,000 kw-hr. per year as the maximum possible output from water power. We already use the equivalent of 30 per cent more mechanical power than this, and in 1928 our central-station and industrial generation was about this same amount, namely, 120,000,000,000 kw-hr. Hydraulic power has been averaging from 33 to 40 per cent of the total, but the proportion will grow smaller as the years go on—as the newer developments become more costly and further away from markets.

The Steadily Decreasing Cost of Steam-Generated Power

Meanwhile the output of steam central stations has grown to about 53,000,000,000 kw-hr. per year and is increasing at the rate of about 10 per cent per year. In 1919 the 24,000,000,000 kw-hr. generated by steam cost on the average 3.2 lb. of coal per kw-hr. By 1928 station economy had been so much improved that the average cost for the 53,000,000,000 kw-hr. that year amounted to only 1.79 lb. of coal per kw-hr. More than twenty of the larger stations now use less than 1.5 lb. of coal per kw-hr., and six are averaging at or about 1 lb. of good coal per kw-hr. We may look confidently toward a further 30 per cent decrease in the use of coal in the central-station industry.

Large units cut down the cost of labor, supplies, and maintenance, and while in this discussion the figure of 0.15 cent has been used there are numerous precedents to show that this might better be put at 0.08 cent. However, 0.15 cent more nearly represents average conditions today. Units of 100,000 kw. and over are becoming common, and the coming years should show considerable reductions in the operating figures.

Water turbines, on the other hand, are very efficient, 92 to 94 per cent, and the overall efficiency of hydro plants may be as high as 90 per cent, leaving very little chance for improvement. With the steadily increasing cost of water rights, real estate, hydro construction, and transmission lines the cost of hydroelectric power will attain higher and higher values, shifting the economic balance further toward steam power. This statement is probably true for conditions in the United States, notwithstanding the proposed construction of such developments as Boulder Dam and the St. Lawrence Canal, where the power rentals are expected to pay irrigation costs in one case and navigation costs in the other. On the Pacific slope, oil is being quoted at $3.60 per ton, while there are sites in the East where $1 coal is available. Thus each proposition is unique, to be considered by itself as to cost, layout, markets, water and fuel supply, rainfall, and storage; but when the costs are known it then becomes a question of how long the static condition is to continue. Here the knowledge of the engineer, the genius of the executive, and the judgment of the financier must combine to determine the proper decision.

The Centenary of Reuleaux

AMONG the many notable German professors of engineering who by their work in the nineteenth century did much to raise the standard of construction, not only in that country but throughout the world, few were better known than Franz Reuleaux, who was born at Eschweiler, near Aachen, on September 30, 1929, and who died in Berlin on August 20, 1905. Trained as a youth in the shops, Reuleaux, between 1850 and 1854, was a student at Karlsruhe, Bonn, and Berlin, and then, for two years, was a works manager at Cologne. His life's work as a teacher and writer of textbooks began with his appointment as professor of mechanics and technics at the Zurich Polytechnic School in 1856. From Zurich he went, in 1864, as a professor to the Berlin Technical Institute, of which he was for many years the director, and, in 1879, he became a professor in the Charlottenburg Technical High School. As a student he had collaborated in writing a paper on the strength of materials, in which he called attention to the molecular stresses of metals and also to the importance of taking into account the limit of elasticity together with the breaking strain, and thus laid the foundation of scientific engineering design. In 1865 he published a handbook for machine design, "Der Konstrukteur," and eleven years later, in 1875, his work "Theoretischen Kinematik," an English translation of which, under the title "The Kinematics of Machinery," was published the following year by the late Sir Alexander Kennedy. Reuleaux served on the juries of the international exhibitions of London (1862), Paris (1867), and Vienna (1873), and in 1876 was appointed the representative of the German Government at the Centennial Exhibition at Philadelphia. Both by his teaching and his writings he did much for engineering in Germany, and his views as a mechanical engineer justly carried great weight.—*Engineering*, September 27, 1929, p. 418.

Recent Research on the Thermal Properties of Steam

A Compilation of Some of the More Reliable Recent Experimental Work on Steam, and Comparisons Thereof Which Reveal a Gratifying Degree of Consistency

By HARVEY N. DAVIS[1] and JOSEPH H. KEENAN,[2] HOBOKEN, N. J.

THE purpose of this paper is to collect in convenient form some of the more reliable recent experimental data on the thermal properties of steam, and to exhibit some comparisons between them. These experiments may be considered in three groups: those dealing with the liquid, those dealing with the process of evaporation, and those dealing with the superheated vapor. Obviously, at and above the critical point the first and last groups of experiments merge into each other, but the classification happens to be a convenient one nevertheless.

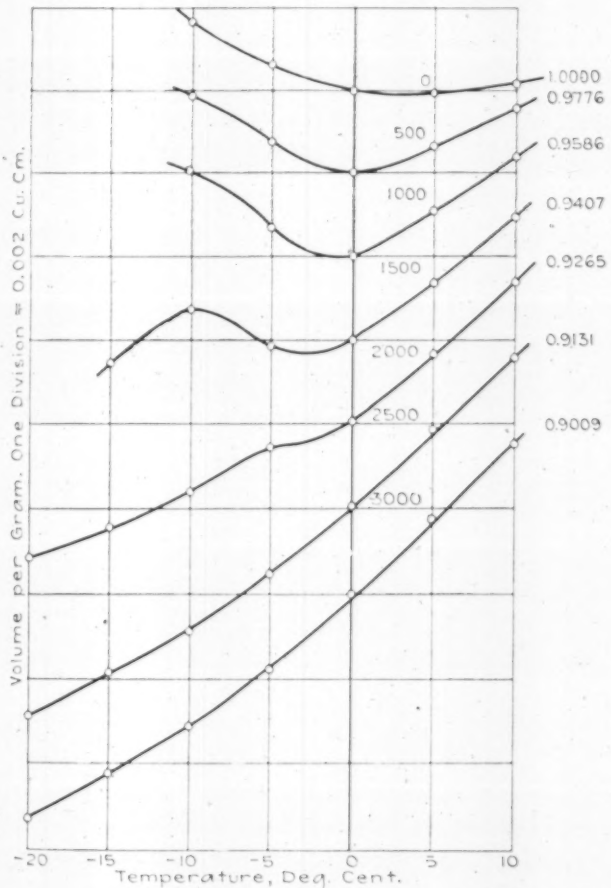

FIG. 1 BRIDGMAN'S CURVES SHOWING RELATIONS BETWEEN VOLUME AND TEMPERATURE OF WATER FOR VARIOUS PRESSURES

(The numbers in the body of the diagram show the constant pressure of each curve in atmospheres; the numbers at the right show the volume at 0 deg. cent. of the liquid at the indicated pressure. If drawn to scale the curves should be separated about ten times as much as shown.)

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Presented at the World Engineering Congress, Tokyo, Japan, October 29 to November 22, 1929.

EXPERIMENTAL WORK DEALING WITH THE LIQUID

As to the liquid, two sorts of experimentation are important, the first leading to knowledge of specific volumes, densities, compressibilities, coefficients of thermal expansion, and the like, and the second giving information about specific heats, entropies, and total heats.

Density. Very exact values of the density of water at low pressures and temperatures have been available for some time, and are summarized in the standard tables of physical constants. At low temperatures but very high pressures we have the work of Bridgman, which is interesting as showing the disappearance, as the pressure increases, of the point of minimum specific volume in the constant-pressure curves. (Fig. 1.[3])

The high-temperature range has recently been covered with a network of density measurements by Keyes and Smith of the Massachusetts Institute of Technology in Cambridge, Massachusetts. Their work covers a band along the orthobaric liquid line up to and including the critical point. Their observations have not yet been completely reduced; when they become available, the situation as regards liquid densities will presumably be satisfactory.

Specific Heat. The specific heat of liquid water is, apparently, a peculiarly difficult property to measure with satisfactory exactness even at temperatures below the normal boiling point. Not only the absolute values of the specific heat of water at various temperatures between 0 deg. and 100 deg. cent. in mechanical or electrical units, but even the relative values in terms of any definable calorie or B.t.u., have been, at least until very recently, in a most chaotic condition. This puts the science of thermodynamics in the anomalous position of depending on a fundamental unit of heat which is not experimentally reproducible with satisfactory accuracy even in the foremost standardizing laboratories of the world, which is not known in its relation to other units of energy to better than a tenth of a per cent, and which is not even defined with precision[4] or in a way that is universally accepted.

Such uncertainty in the very foundation of a great branch of science is intolerable. In our opinion, there are only two fundamentally sound ways of meeting the difficulty. The first is to abandon altogether, by international agreement, all attempts to define the calorie or the B.t.u. in terms of the properties of water, and to adopt instead a definition based entirely on an arbitrarily selected and not-to-be-tampered-with value of the electrical or mechanical equivalent of the new heat unit. The specific heat of water could then be measured in terms of the international calorie or B.t.u. in precisely the same way that the

[3] Reproduced from *Proc. Am. Acad. Arts & Sci.*, vol. 47, no. 13, Jan., 1912, pp. 441–558. See also *Zeit. für Anorg. Chem.*, vol. 77, Oct., 1912, pp. 377–455; and MECHANICAL ENGINEERING, vol. 47, no. 3, March, 1925, pp. 161–169.

[4] Not only is there disagreement as to whether the 15-deg. calorie, the 16.5-deg. calorie, the 20-deg. calorie or the mean or Bunsen calorie should be made fundamental; but the question has not been settled as to whether the chosen calorie should be that at atmospheric pressure or that at saturation pressure. In this paper, as far as possible, all liquid specific heats are at saturation pressure.

specific heats of other substances are so measured. Presumably the arbitrarily selected value of the electrical or mechanical equivalent should be such that the average specific heat of water over the usual range of experience is approximately one. Presumably also, if both the calorie and the B.t.u. are to be retained, their ratio to each other should be exactly as at present, so that entropies should be the same in both metric and English units.

This proposal is exactly analogous to what has happened with respect to the standard value of the acceleration of gravity. This was originally defined as the value at 45 deg. and sea level. Presently an international congress decided that the best-known value at 45 deg. and sea level was 980.665 cm. per sec. per sec. When, some years later, doubt arose as to the accuracy of this

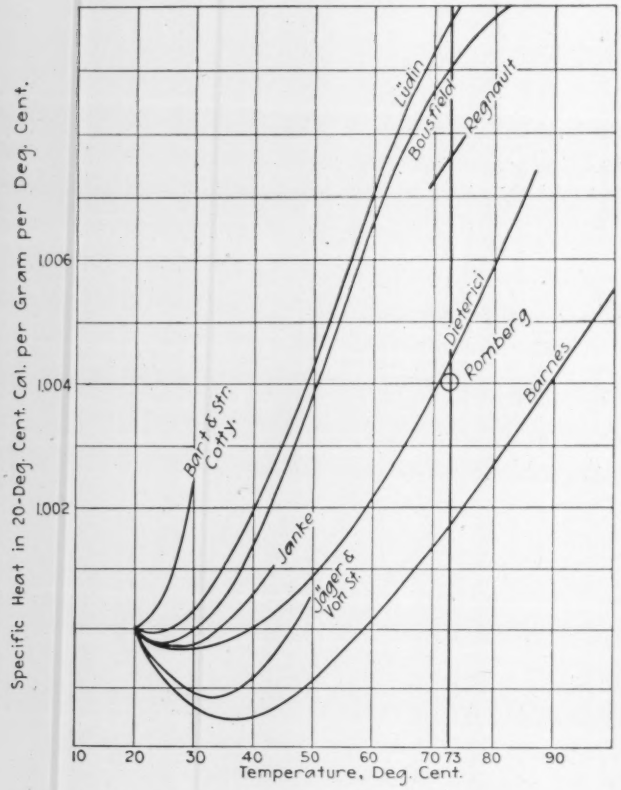


FIG. 2 EXPERIMENTAL STATUS OF LIQUID SPECIFIC HEATS BEFORE THE PRESENT BUREAU OF STANDARDS PROGRAM WAS STARTED

experimental value, the 45-deg. and sea-level part of the definition was dropped, and g_0 is now universally defined in terms of the number, and not in terms of any particular spot on the earth. If this outcome could have been foreseen, it would have been much more sensible to have agreed on a simpler numerical value, say, 980 cm. per sec. per sec., in the first place. Similar remarks apply to the legal definitions of the American yard and pound. Both are, by act of Congress, prescribed fractions of the corresponding metric units, but while the exact official conversion factor for the yard involves only four digits, that for the pound involves eight where four or five would have done just as well. In defining the calorie or the B.t.u. these lessons should be remembered, and due regard should be had to the numerical simplicity or "roundness" of the mechanical or electrical equivalent selected as the basis of the fundamental definition.

A second solution of the difficulty with regard to the fundamental unit of heat is to abandon the calorie and the B.t.u. altogether, and to express all thermal quantities in kilowatt-seconds or kilojoules. This practice is already practically universal in the laboratories where the original measurements are made. The results are now, however, carefully translated over into uncertain thermal units in our published steam and other tables, only to be, in many cases, carefully translated back again into electrical units if the user of the tables is, as is increasingly probable, concerned with some problem in the modern power

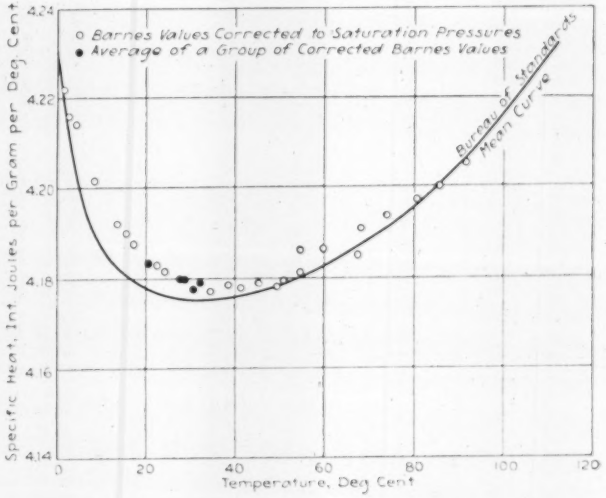


FIG. 3 BARNES' OBSERVATIONS OF THE SPECIFIC HEAT OF THE LIQUID COMPARED WITH NEW BUREAU OF STANDARDS VALUES

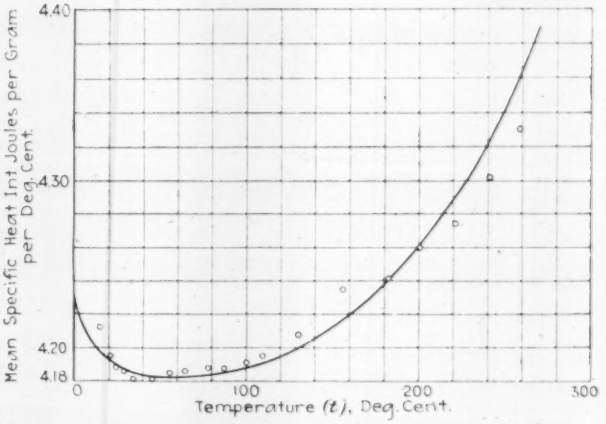


FIG. 4 DIETERICI'S OBSERVATIONS OF THE MEAN SPECIFIC HEAT OF THE LIQUID AT SATURATION PRESSURES BETWEEN 0 DEG. CENT. AND t DEG. CENT. COMPARED WITH NEW BUREAU OF STANDARDS VALUES

plant. A set of steam tables whose only heat unit was the kilojoule would be more convenient than our present tables for many purposes, and less convenient for no purpose whatever that we can think of. Even in calorimetry (the only apparent exception) the variation of the specific heat of water with temperature makes recourse to tabulated rather than remembered values of specific heats or total heats indispensable, and such computations can be handled quite as easily in kilojoules as in calories or B.t.u.

We feel strongly that one or the other of these proposals, namely, definition of the B.t.u. or calorie as a round number of electrical or mechanical units, or the use of the kilowatt-

second as the unit for thermal quantities, should be adopted by international agreement at the earliest possible date; and of the two proposals we much prefer the second.

The chaotic situation with respect to the specific heat of water is shown in Fig. 2,[5] in which the thermal unit is the 20-deg.

TABLE 1 RESULTS OF MEASUREMENTS AT THE BUREAU OF STANDARDS OF THE HEAT CAPACITY OF SATURATED LIQUID WATER

Temperature, deg. cent.	Total heat, Int. joules per gram	Temperature, deg. cent.	Total heat, Int. joules per gram
10	42.01	160	675.09
20	83.84	170	718.76
30	125.62	180	762.78
40	167.34	190	807.21
50	209.12	200	852.14
60	250.92	210	897.46
70	292.77	220	943.26
80	334.69	230	989.77
90	376.66	240	1037.03
100	418.76	250	1085.05
110	460.98	260	1134.07
120	503.35	270	1184.09
130	545.92	...	.....
140	588.72	...	.....
150	631.78	...	.....

TABLE 2 SPECIFIC HEAT OF WATER—H. T. BARNES

(*Philosophical Transactions*, vol. 199A (1902), pp. 149–263)

Temp., deg. cent.	Atm. press. spec. ht. observed, Int. joules, per gram per deg. cent.	Spec. ht. corrected to saturation pressures, Int. joules per gram per deg. cent.	Temp., deg. cent.	Atm. press. spec. ht. observed, Int. joules per gram per deg. cent.	Spec. ht. corrected to saturation pressures, Int. joules per gram per deg. cent.
1.35	4.2215	4.2215	29.92	4.1772	4.1774
2.68	4.2155	4.2156	30.54	4.1767	4.1770
4.28	4.2138	4.2139	31.22	4.1771	4.1774
8.66	4.2009	4.2010	31.40	4.1773	4.1776
13.79	4.1913	4.1914	32.17	4.1775	4.1778
15.71	4.1893	4.1894	32.26	4.1781	4.1784
17.09	4.1870	4.1871	32.81	4.1778	4.1781
17.69	4.1870	4.1871	34.46	4.1765	4.1768
20.13	4.1833	4.1834	38.76	4.1777	4.1781
20.18	4.1838	4.1839	41.02	4.1773	4.1777
20.45	4.1824	4.1825	45.49	4.1784	4.1789
20.92	4.1830	4.1832	49.68	4.1777	4.1783
22.16	4.1827	4.1829	51.02	4.1785	4.1791
24.20	4.1813	4.1815	54.57	4.1801	4.1809
28.01	4.1796	4.1798	54.61	4.1844	4.1852
28.52	4.1792	4.1794	59.80	4.1849	4.1858
28.77	4.1793	4.1795	67.52	4.1834	4.1847
29.09	4.1803	4.1805	68.21	4.1890	4.1903
29.11	4.1795	4.1797	74.05	4.1920	4.1936
29.13	4.1795	4.1797	80.38	4.1951	4.1971
29.21	4.1790	4.1792	85.60	4.1978	4.2002
29.43	4.1791	4.1793	91.55	4.2017	4.2052
29.47	4.1792	4.1794	....	....	....

TABLE 3 MEAN SPECIFIC HEAT OF WATER AT SATURATION PRESSURES BETWEEN 0 DEG. AND t DEG. CENT.—C. DIETERICI

[*Annalen der Physik* (4), vol. 16 (1905), pp. 593–620]

Given in Bunsen mean calories = 4.1925 mech. joules per gram per deg. cent. = 4.191 Int. joules per gram per deg. cent.

Temp., deg. cent.	C_m Int. joules per gram per deg. cent.	Temp., deg. cent.	C_m Int. joules per gram per deg. cent.
14.58	4.212	100.00	4.191
20.69	4.195	109.7	4.195
24.53	4.189	130.75	4.207
29.28	4.186	156.12	4.235
34.62	4.181	182.6	4.241
45.85	4.181	200.4	4.260
55.7	4.185	221.2	4.274
64.63	4.186	240.9	4.302
78.00	4.188	259.00	4.330
87.77	4.187	303.3	4.395

calorie. Our only addition to the information summarized in this figure is an extensive experimental program at the Bureau of Standards in Washington, D. C. This work is as yet neither published nor entirely completed. Their latest[6] values, privately communicated for this paper, are given in Table 1. These results are compared with the original data (Table 2) of Barnes (probably the most reliable of previous experimenters) in Fig. 3, and with those (Table 3) of Dieterici (the only previous experimenter, except Regnault, to work at temperatures above 100 deg. cent.) in Fig. 4.

The Bureau of Standards work gives 1.0031 as the ratio of the calorie at 73 deg. cent. to that at 20 deg. cent., as against Romberg's[5] experimentally determined 1.0043, both being reduced to saturation pressures. Another interesting comparison can be made with the single experimental fact in Callendar's paper of 1912.[7] He says, "It may be said that formula [10] is verified to at least 1 in 5000 for the ratio of the mean specific heat from 69 deg. cent. to 100 deg. cent., to the mean specific heat from 25 deg. cent. to 56 deg. cent. Formula [10] gives 1.0050 for the ratio."

This apparently means that, according to Callendar's experimental observations, the mean specific heat of water between 69 deg. cent. and 100 deg. cent. is 1.00545 times that of the same quantity of water between 25 deg. cent. and 56 deg. cent., both averages being at saturation pressure. The Bureau of Standards results lead to 1.00548 as the value of this ratio, a remarkable agreement.

EXPERIMENTAL DATA OBTAINED ON EVAPORATION

Turning next to the two-phase region and the process of evaporation, there are again two important sorts of experimental data, the saturation pressure-temperature relation, and latent heats.

Saturation Pressure-Temperature Relation. Reliable saturation pressures have been available for some time, thanks to the work of various observers at the Reichsanstalt in Charlottenburg.[8] A check on their work has come as a by-product of the specific-volume measurements of Keyes and Smith at the Massachusetts Institute of Technology. Their latest results, privately communicated for this paper, are given in Table 4.

TABLE 4 OBSERVATIONS OF VAPOR PRESSURES—KEYES AND SMITH

[Revised figures of December, 1928. (Privately communicated)]

Temperature, deg. cent.	Vapor pressure, kg. per sq. cm.	Temperature, deg. cent.	Vapor pressure, kg. per sq. cm.
160.00	6.304	320.00	115.148
160.00	6.299	320.00	115.168
170.00	8.086	320.00	115.184
170.00	8.073	330.00	131.299
180.00	10.228	330.00	131.259
190.00	12.787	340.00	149.088
200.00	15.848	340.00	149.157
200.00	15.842	340.00	149.115
210.00	19.443	350.00	168.787
220.00	23.650	350.00	168.818
230.00	28.506	350.00	168.749
240.00	34.102	355.00	179.409
250.00	40.534	360.00	190.607
260.00	47.849	360.00	190.571
270.00	56.114	360.00	190.527
280.00	65.412	365.00	202.295
290.00	75.865	370.00	214.775
300.00	87.621	371.00	217.334
300.00	87.206	372.00	219.949
310.00	100.647	373.00	222.652
310.00	100.680	374.00	225.438
310.00	100.695	374.00	225.434
310.00	100.659	....	....

Critical point, 374.11 deg. cent.; pressure, 225.69 kg. per sq. cm.

Table 5 gives the Reichsanstalt values above 200 deg. cent. and Fig. 5 compares them with the M.I.T. values; the agreement is excellent. It is expected that an additional check on the pressure-temperature relationship will presently emerge as a by-product of the work now in progress at the Bureau of Standards.

The chief outstanding uncertainty with respect to the vapor-pressure curve is as to the position of the critical point. It is

[5] From Romberg, *Proc. Am. Acad. Arts & Sci.*, vol. 57 (1922), pp. 377–387.

[6] Feb. 28, 1929.

[7] *Phil. Trans.*, vol. 212A (1912), pp. 1–22.

[8] 1½ to 50 deg. cent.: Scheel and Heuse, *Ann. der Phys.* (4), vol. 31 (1910), pp. 715–736. 50 to 204 deg. cent.: Holborn and Henning, *Ann. der Phys.* (4), vol. 26, pp. 833–883. 200 to 374 deg. cent.: Holborn and Baumann, *Ann. der Phys.* (4), vol. 31 (1910), pp. 945–970.

comparatively easy to extend the vapor-pressure curve smoothly past the critical point for ten or twenty degrees by plotting pressure against temperature at specific volumes approximately equal to the critical volume; but it is difficult to tell where one part of the curve stops and the other begins by any experimental technique other than actual observation of the disappearance of the meniscus in a Caignard de la Tour tube, an experiment so beset with difficulties because of the extreme solubility of all

TABLE 5 PRESSURE-TEMPERATURE RELATIONSHIP AT SATURATION—HOLBORN AND BAUMANN

(Corrected to International Temperature Scale—Sulphur Point = 444.6°C.)
Original figures given in *Annalen der Physik* (4), vol. 31 (1910), pp. 945–970.

Temp., deg. cent.	Pressure, kg. per sq. cm.	Temp., deg. cent.	Pressure, kg. per sq. cm.
200.93	16.168	335.94	141.61
202.09	16.553	341.12	151.03
214.01	21.061	347.03	162.50
219.80	23.574	348.12	164.85
230.83	28.952	353.65	176.18
240.97	34.713	356.48	182.44
250.32	40.750	358.05	185.76
261.87	49.315	362.00	194.92
271.66	57.560	364.48	200.79
281.21	66.629	365.06	202.13
291.93	78.061	368.12	209.71
301.66	89.75	370.00	214.28
310.97	102.15	370.70	216.43
321.43	117.40	373.13	222.67
330.24	131.57	373.80	224.47
334.91	139.60	....	....

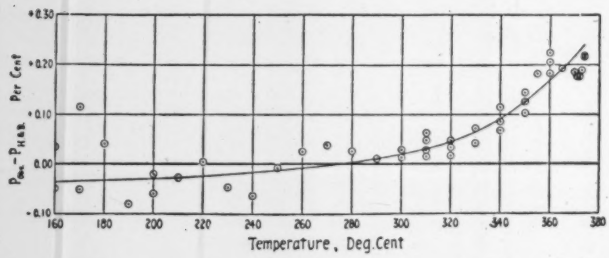


FIG. 5 DIFFERENCE BETWEEN KEYES-SMITH AND HOLBORN-BAUMANN VALUES FOR THE VAPOR PRESSURE IN PER CENT OF THE PRESSURE

available transparent containers in hot water, that it has not yet been successfully accomplished. We are here assuming that a critical point of the traditional sort actually exists; whether Callendar's recent suggestion[9] that this is not the case is convincing or not will be discussed later in this paper.

Latent Heats. On latent heats below 100 deg. cent. fairly reliable experimental determinations by Dieterici,[10] Griffiths,[11] Smith,[12] and Henning[13] have been available for some time. At 100 deg. cent. the best determinations are probably the following:

Richards and Matthews[14] . . . 2251.3 Int. joules per gram
Henning[13] . . . . . 2256.06 Int. joules per gram
A. W. Smith[12] . . . . . 2261.55 Int. joules per gram

The value chosen by Keenan for the current temporary American table[15] is 2257.1 Int. joules per gram.

Above 100 deg. cent. there is the work of Henning[13] (Table 6) and some new work, not yet completed by Jakob[16] at the Reichs-

TABLE 6 LATENT HEATS BETWEEN 100 AND 180 DEG. CENT.—F. HENNING

[*Annalen der Physik* (4), vol. 29 (1909), pp. 441–465]
Electrical equiv., 15-deg. cal. = 4.188 Int. kilojoules

Temp., deg. cent.	Latent heat, Int. joules per gram
102.34	2248.7
120.78	2200.0
140.97	2134.2
160.56	2077.0
180.72	2018.5

TABLE 7 LATENT-HEAT DETERMINATIONS—JAKOB

Temperature, deg. cent.	Latent heat, Int. joules per gram
180	2010.8
210	1896.6
230	1809.6
250	1713.4

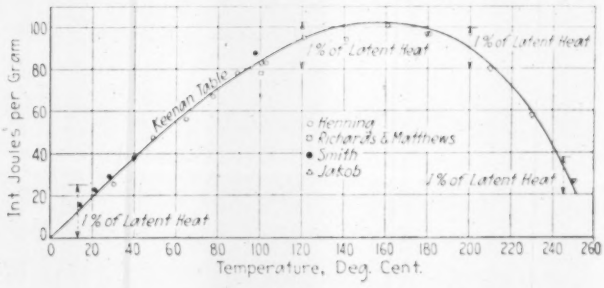


FIG. 6 COMPARISON OF VARIOUS LATENT-HEAT OBSERVATIONS
(To magnify the scale of latent heats, the differences of the values from a chord of the latent-heat curve are plotted.)

anstalt. His latest values, privately communicated for this paper, are given in Table 7.

These and other experimental values are compared with each other in Fig. 6, which is a large-scale plot of residuals above a conveniently chosen chord of the usual latent-heat-against-temperature diagram. The four sets of experimental data are seen to be in reasonably satisfactory agreement with each other. The curve in Fig. 6 represents the values chosen by Keenan for the current temporary American table. Its agreement with Jakob's four experimental values is most satisfactory when it is remembered that the curve was determined from American data before Jakob's definitive values at 180 deg. cent. and 210 deg. cent. were available, and before any information whatever as to his values at 230 deg. cent. and 250 deg. cent. had reached us. This is a valuable cross-check between Jakob's work and the American experimental work which is to be described later.

EXPERIMENTS DEALING WITH SUPERHEATED VAPOR

It is in the superheated-vapor region (and as a matter of convenience we include under this head the neigh'borhood of the critical point) that most of the recent experimental work on the properties of steam has been done. This work has been of four sorts: (*a*) specific volumes, by Keyes and Smith at M.I.T.; (*b*) specific heats, by Knoblauch and his co-workers at the Technische Hochschule in Munich; (*c*) total heats, by Callendar at the Imperial College of Science in London, and by Havlíček at the Masaryk Academy of Work in Prague; and (*d*) Joule-Thomson coefficients, by Davis and Kleinschmidt at Harvard University, Cambridge, Massachusetts. The range covered by each of these five sets of experiments (and by some others) is shown on the temperature-entropy plane in Fig. 7, and on the pv/RT vs. p plane in Fig. 8. It will be seen that these five experimental programs overlap so as to cover practically the whole superheated field from atmospheric pressure to the critical point, and from saturation to a temperature close to 400 deg. cent. or 750 deg. fahr.

[9] "Steam Tables and Equations Extended by Direct Experiment to 4000 Lb./Sq. In. and 400°C." H. L. Callendar, Proc. Roy. Soc., vol. A 120 (1928), pp. 460–472.

[10] *Ann. der Phys.* (*Wied. Ann.*), vol. 37 (1889), pp. 494–508.

[11] *Phil. Trans.*, vol. A 186 (1895), pp. 261–341.

[12] *Physical Review*, vol. 25, no. 3, Sept., 1907, pp. 145–170.

[13] 30 to 100 deg. cent., *Ann. der Phys.* (4), vol. 21 (1906), pp. 849–878; 100 to 180 deg. cent., *Ann. der Phys.* (4), vol. 29 (1909), pp. 441–465.

[14] *Jl. Am. Chem. Soc.*, vol. 33 (1911), pp. 863–888.

[15] See MECHANICAL ENGINEERING, vol. 51, no. 2, Feb., 1929, pp. 109–115.

[16] *Forschungsarbeiten*, no. 310, 1908, pp. 9–19; *Z.V.D.I.*, vol. 73, no. 3, Jan. 19, 1929, pp. 82–84.

Specific Volume. The Keyes and Smith M.I.T. data so far reported are given in Table 8. The experimenters consider the first measurements as the more reliable. Further experiments are now[17] in progress in the region between the present M.I.T. data and the Harvard Joule-Thomson data, which will afford a valuable comparison with the latest work of Knoblauch in this same region.

Specific Heat. Knoblauch and his co-workers in Munich have published five papers on the specific heat of superheated steam, the data in which are given in Tables 9 to 13, inclusive.

There is also an isolated but very useful and dependable C_p value by Brinkworth,[18] a co-worker of Callendar in London, namely: $C_p = 2.0300$ Int. joules per gram per deg. cent. at 760 mm. Hg abs. and 104.5 deg. cent.

Total Heat. Callendar himself has been measuring specific heats and total heats in London for several years, but, as yet, none of his specific-heat work, and only a very little of his total-heat work, is available in the form of actual experimental data. In his Howard lectures of 1926 he showed one diagram, since published in various places,[19] from which, with the help of his then current steam tables, some 52 experimental determinations of total heats can be reconstructed. They lie in a band between pressures 700 and 1000 lb. per sq. in. and extend from saturation to about 250 deg. fahr. of superheat. Because of the uncertainty of the reconstruction of this mass of data from a published diagram, we have not attempted to tabulate it; we show a graphical intercomparison of it with other data later in this paper (Fig. 12). Callendar has also recently distributed privately a much less extensive group of total-heat data taken in the neighborhood of the critical point; these also will be exhibited graphically later in this paper.

The work of Havliček[20] is, in kind, much like some of Callendar's. Both determine total heats by throttling to about atmospheric pressure, where the pressure and temperature are measured and the total heat found from the Callendar tables in the case of Callendar, and from the Mollier tables in the case of Havliček. Both also use the alternative method of condensing the steam after throttling and determining the total heat from the rise in temperature of the cooling water, though Havliček seems to have more faith in the first method. Havliček's experi-

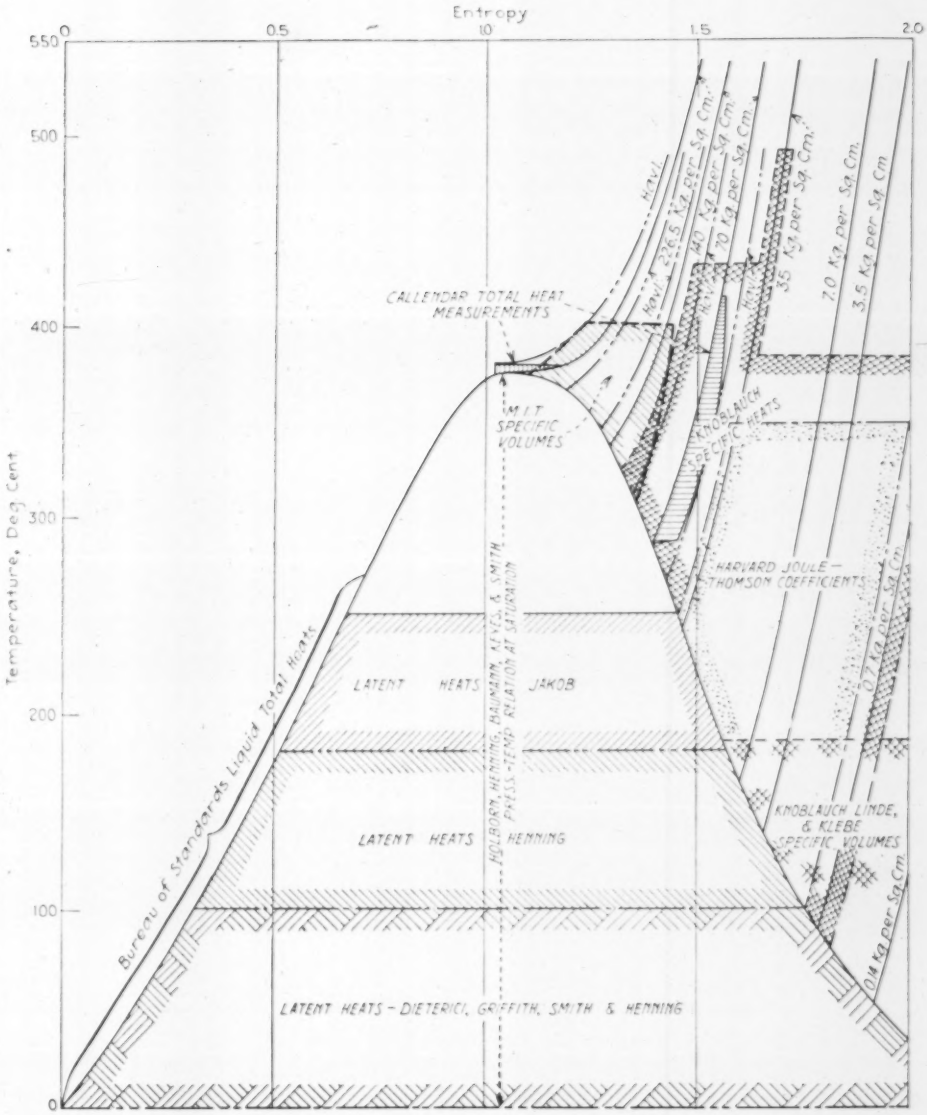


FIG. 7 TEMPERATURE-ENTROPY DIAGRAM SHOWING THE EXTENT OF VARIOUS RESEARCHES
(The lines marked "Havl." are the pressures along which Havliček is measuring total heats.)

TABLE 8 SPECIFIC-VOLUME DETERMINATIONS—KEYES AND SMITH

(*Mechanical Engineering*, vol. 50, no. 2, Feb., 1928, pp. 153–155; vol. 51, no. 2, Feb., 1929, pp. 124–125)

Temp., deg. cent.	Specific volume (cu. cm. per gram) 5.000	6.250	7.500	10.000	12.500	15.000	17.500	20.000
	Pressures in kg. per sq. cm.—1st measurements							
310	....	....	....	.....	.....	.....	.....	95.07
320	....	....	....	.....	.....	.....	107.26	98.94
330	....	....	....	.....	.....	121.94	111.77	102.71
340	....	....	....	.....	139.78	127.33	116.12	106.34
350	....	....	....	161.51	146.44	132.53	120.37	109.88
360	....	....	187.22	170.20	152.99	137.64	124.51	113.35
370	....	208.50	199.36	178.65	159.26	142.59	128.56	116.76
380	233.19	223.07	211.17	186.85	165.41	147.43	132.52	120.10
390	251.28	237.30	222.63	194.89	171.42	152.18	136.40	123.38
400	269.08	251.22	233.83	202.75	177.35	156.82	140.20	126.57
	1st measurements minus 2nd measurements in per cent							
310	....	....	....	.....	.....	.....	.....	−0.022
320	....	....	....	.....	.....	.....	+0.010	−0.010
330	....	....	....	.....	.....	+0.034	+0.019	+0.040
340	....	....	....	.....	+0.044	+0.024	+0.027	+0.078
350	....	....	....	+0.038	+0.049	+0.031	+0.069	+0.038

Average deviation, 0.036.

[17] April 1, 1929.

[18] *Phil. Trans.* (A), vol. 215 (1915), pp. 383–438.

[19] Roy. Soc. of Arts, Howard Lecture, Nov. 29, 1926. Also B.E.A.I. Res. Assoc., Technical Rept. Ref. J/T 32.

[20] MECHANICAL ENGINEERING, vol. 51, no. 2, Feb., 1929, pp. 127–128; World Power Conf., Fuel Conf., 1928, no. J2.

mental data are as yet available only in graphical form. Selected portions of them will be exhibited graphically later in this paper.

Joule-Thomson Coefficients. The Harvard work on the Joule-Thomson coefficients differs from Callendar's throttling experiments chiefly in that pressure and temperature drops were always small, so that the differential coefficient

$$\mu = (\partial t/\partial p)_h$$

was determined at various points in the superheated region; whereas Callendar determined by a single experiment the two extremities of a long throttling curve stretching across a considerable part of the plane. The Harvard data have not yet been published, but the definitive experimental results are given in Table 14.

An older Joule-Thomson measurement by Trueblood[21] in the same laboratory gave the value 3.182 deg. cent. per kg. per sq. cm. ± 0.5 per cent, at 165 deg. cent. and 386 kg. per sq. cm.

Inasmuch as these four kinds of data are dissimilar, any intercomparisons between them must be indirect. One such intercomparison between the older Knoblauch data[22] and the

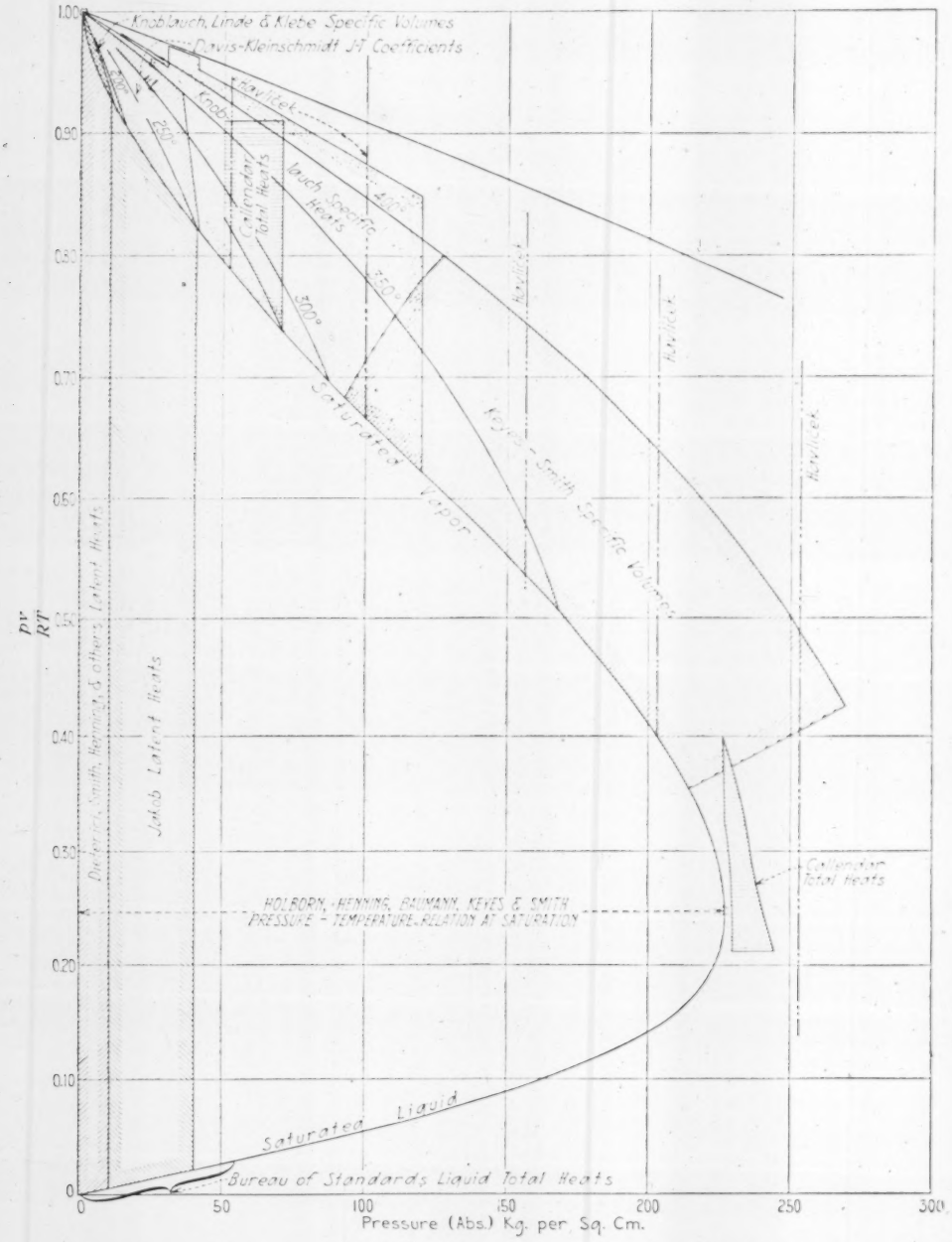


FIG. 8 THE EXTENT OF VARIOUS RESEARCHES SHOWN ON THE (pv/RT)-p PLANE
(The pressures along which Havlíček is measuring total heats are indicated.)

[21] *Proc. Am. Acad. Arts & Sci.*, vol. 52, no. 12, June, 1917, pp. 734–804.

[22] First four Knoblauch papers only, Tables 9 to 12.

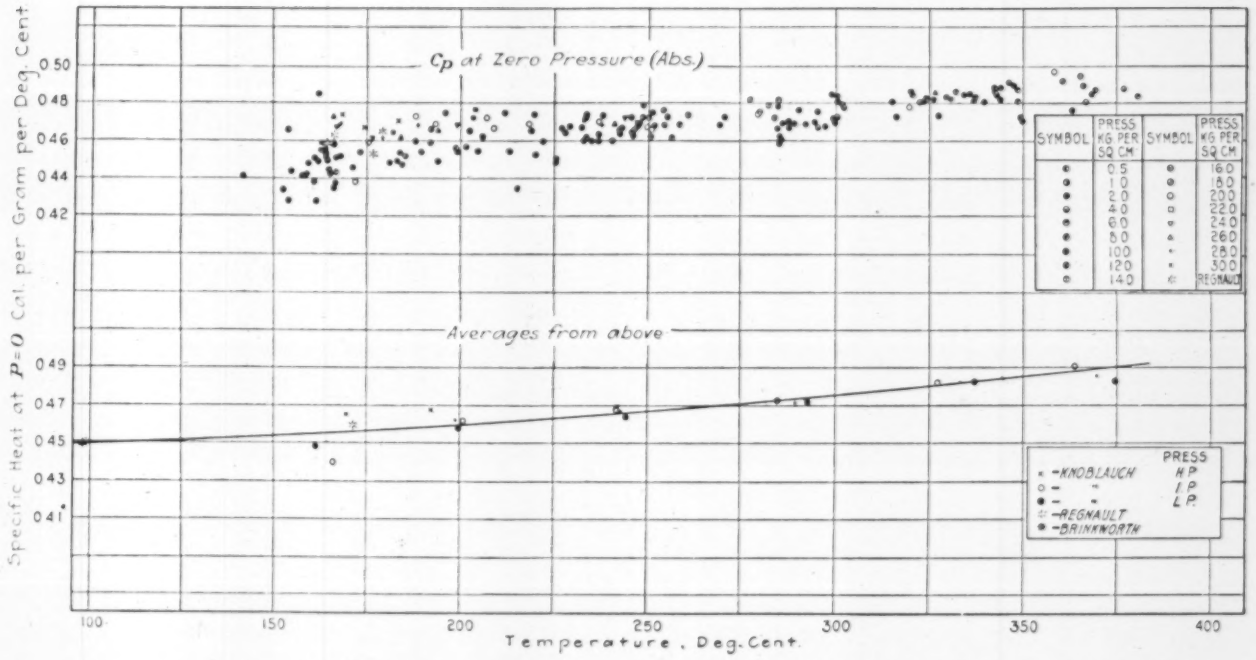
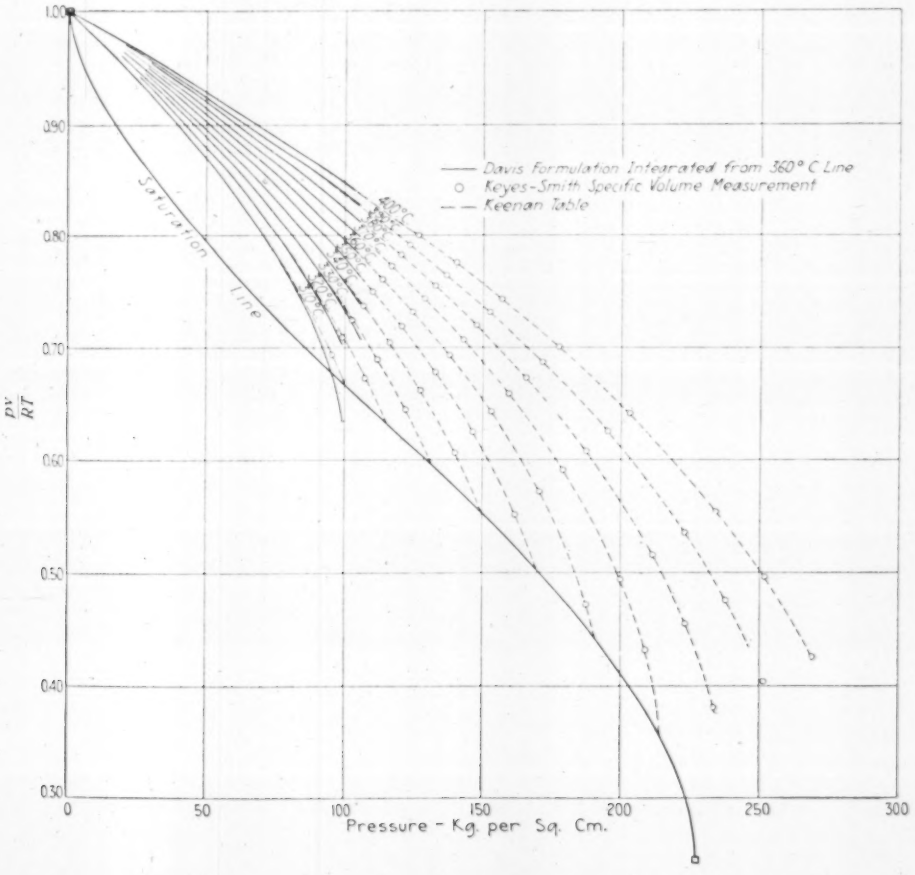


FIG. 9 COMPARISON OF THE DAVIS-KLEINSCHMIDT JOULE-THOMSON MEASUREMENTS WITH THE KNOBLAUCH SPECIFIC-HEAT MEASUREMENTS BELOW 30 KG. PER SQ. CM.

(A specific heat-ratio chart obtained from the Joule-Thomson coefficients was used to "reduce" each of the Knoblauch observed specific heats to "zero pressure.")



1926 version of the Harvard data is shown in Fig. 9.[23] The Harvard μ's were used to determine lines of constant total heat and certain specific-heat ratios. The specific-heat-ratio chart thus made was then used to "reduce" each of the then available Knoblauch observed C_p's "to zero pressure." The result is plotted in Fig. 9. If there were a systematic discrepancy between the two bodies of data, the band of points in Fig. 9 would be stratified; that is, the points originating in observations at the highest pressures would be consistently above or

[23] Reprinted from Keenan, MECHANICAL ENGINEERING, vol. 48, no. 2, Feb., 1926, p. 145.

FIG. 10 (AT LEFT) COMPARISON BETWEEN DAVIS FORMULATION OF THE HARVARD JOULE-THOMSON COEFFICIENTS AND THE KEYES-SMITH SPECIFIC-VOLUME MEASUREMENTS

(The formulation of the Joule-Thomson coefficients, supplemented by a curve of specific heat at zero pressure obtained with the aid of the Knoblauch specific-heat measurements, yielded a complete set of total heats. From these could be found the variation in specific volume at constant pressure. The figure shows this variation from the 360-deg. cent. line as a base. The dash lines are from the Keenan tables and show the ease with which the two sources of data could be reconciled.)

TABLE 9 SPECIFIC HEAT OF SUPERHEATED STEAM —KNOBLAUCH AND JAKOB

[*Z.V.D.I.*, vol. 55 (1911), pp. 665–673. Recalculated, using Mollier tables to get pressure correction. Originally reported in *Forschungsarbeiten*, Heft. 35, p. 109, and *Z.V.D.I.*, vol. 51 (1907), pp. 81–88. Electrical equiv.: 1 kilocal. = 4.186 Int. kilojoules]

Exp. no.	Pressure, kg. per sq. cm.	Temp., deg. cent.	C_p Int. joules per gram per deg. cent.
1	2.01	149.1	2.009
2	2.02	188.2	1.984
3	2.00	240.4	1.988
4	2.00	245.9	2.000
5	2.02	296.6	2.000
6	2.01	345.9	2.059
7	2.02	349.3	2.084
8	4.00	170.6	2.110
9	3.99	210.5	2.050
10	4.01	260.8	2.038
11	3.98	304.7	2.030
12	3.98	306.1	2.067
13	4.01	306.5	2.059
14	4.00	350.3	2.101
15	6.00	180.2	2.223
16	6.00	217.5	2.110
17	6.01	259.8	2.063
18	5.98	306.4	2.051
19	6.01	349.6	2.106
20	8.00	188.1	2.331
21	8.00	240.0	2.084
22	8.00	295.0	2.055
23	8.00	295.2	2.046
24	8.00	295.7	2.084
25	7.99	344.9	2.101
26	7.98	349.8	2.118
27	8.00	356.0	2.114

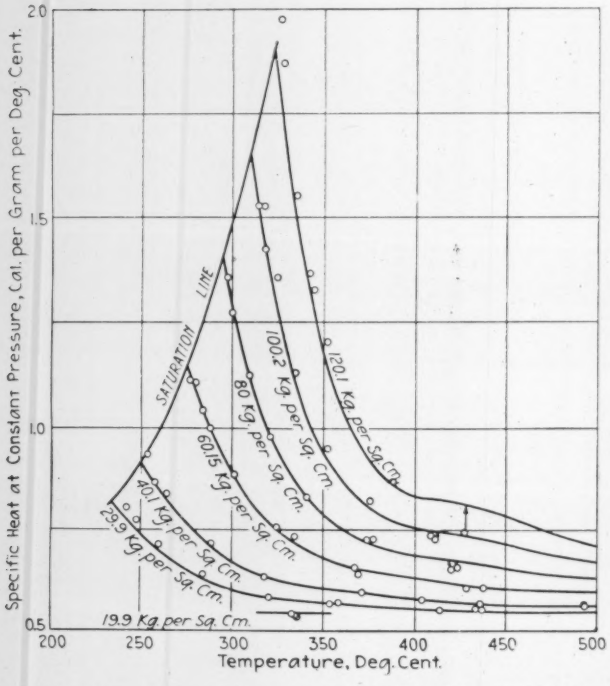


FIG. 11 COMPARISON OF KNOBLAUCH AND KOCH EXPERIMENTS OF 1928 WITH KEENAN TABLES

(The lines are from the Keenan tables; the circles are the Knoblauch measurements. This figure constitutes a comparison between the American and Knoblauch experiments.)

below those originating in observations at low pressures. No such stratification appears; it follows that the two bodies of data are in substantial agreement. It might be mentioned that, since the Harvard data had been smoothed as a part of the computation process, the width of the band of points in Fig. 9 is a measure of the experimental uncertainty in Knoblauch's individual observations.

The comparison described in the last paragraph has not yet been brought up to date as regards either the definitive version of the Harvard data or the fifth and latest paper of Knoblauch and Koch on account of the pressure of other parts of this work. We can, however, exhibit a different sort of indirect comparison between Knoblauch and Koch's work and our work in America.

In the fall of 1928, before the paper of Knoblauch and Koch reached America, Keenan prepared the current temporary American chart and steam table, using the Harvard data, extending to about 40 kg. per sq. cm., as the basis of the low pressure end of the pv/RT vs. p diagram (see Fig. 8), and using the M.I.T. data above 100 kg. per sq. cm. The gap between 40 kg. per sq. cm. and 100 kg. per sq. cm. was bridged partly by graphical interpolation, but largely with the help of an extrapolation of the Harvard data to 110 kg. per sq. cm. that had been independently worked out before the M.I.T. data were available. The amount of adjustment that was necessary to bring the Harvard extrapolation smoothly into the M.I.T. data above 100 kg. per sq. cm. is shown in Fig. 10, and is ex-

TABLE 10 SPECIFIC HEAT OF SUPERHEATED STEAM —KNOBLAUCH AND MOLLIER

[*Z.D.V.I.*, vol. 55 (1911), pp. 665–673. Electrical equiv.: 1 kilocal. = 4.186 Int. kilojoules]

Exp. no.	Pressure, kg. per sq. cm.	Temp., deg. cent.	C_p Int. joules per gram per deg. cent.
1	1.98	161.1	1.984
2	1.98	171.9	2.030
3	2.01	173.7	2.000
4	1.95	193.0	2.034
5	1.98	271.9	1.996
6	2.05	273.0	2.013
7	2.00	325.8	2.034
8	1.98	328.2	2.038
9	1.98	329.6	2.000
10	2.00	365.2	2.008
11	1.99	409.2	2.075
12	1.99	414.2	2.042
13	2.00	429.1	2.080
14	1.99	460.6	2.097
15	1.99	462.3	2.160
16	2.01	466.0	2.089
17	2.01	467.9	2.122
18	1.98	474.2	2.118
19	2.00	500.1	2.156
20	2.00	505.5	2.143
21	1.99	515.8	2.168
22	2.01	533.5	2.114
23	2.00	552.1	2.156
24	1.96	565.4	2.152
25	3.98	171.1	2.101
26	4.01	171.9	2.122
27	3.99	174.2	2.122
28	3.98	174.3	2.131
29	4.00	176.6	2.114
30	4.01	243.6	2.021
31	4.00	247.2	2.017
32	3.98	252.1	2.025
33	3.99	252.3	2.063
34	4.00	253.8	2.042
35	4.00	257.7	2.042
36	3.97	370.2	2.042
37	3.99	405.0	2.089
38	4.01	405.5	2.038
39	4.02	458.8	2.131
40	3.99	469.0	2.152
41	3.97	469.7	2.080
42	3.98	510.9	2.126
43	3.99	514.7	2.173
44	4.00	518.9	2.168
45	3.96	546.4	2.173
46	3.99	551.6	2.193
47	4.03	555.3	2.185
48	4.01	562.5	2.126
49	5.96	180.9	2.269
50	6.00	181.5	2.264
51	6.00	181.7	2.260
52	6.02	187.8	2.181
53	6.02	255.4	2.071
54	5.99	321.3	2.080
55	6.00	330.1	2.084
56	6.02	394.2	2.067
57	6.01	458.2	2.164
58	6.00	516.1	2.198
59	6.00	520.4	2.126
60	5.99	548.1	2.189
61	5.99	572.7	2.185
62	8.05	197.1	2.307
63	8.01	203.8	2.256
64	8.00	268.1	2.089
65	8.01	328.9	2.118
66	7.98	386.7	2.080
67	8.01	404.1	2.139
68	8.01	466.5	2.185
69	8.00	469.5	2.189
70	8.00	514.7	2.202
71	7.97	515.4	2.126

TABLE 11 SPECIFIC HEAT OF SUPERHEATED STEAM —KNOBLAUCH AND WINKHAUS

[*Mitteilungen über Forschungsarbeiten*, no. 194 (1917), pp. 1–20. Electrical equiv.: 1 kilocal. = 4.186 Int. kilojoules]

Exp. no.	Pressure, kg. per sq. cm.	Temp., deg. cent.	C_p Int. joules, per gram per deg. cent.
1	0.48	129.53	1.984
2	0.50	155.18	1.930
3	0.61	200.43	1.908
4	0.50	221.15	2.013
5	0.52	249.65	1.971
6	0.50	300.09	2.000
7	0.51	300.68	2.030
8	0.49	349.97	1.980
9	1.00	111.78	1.984
10	0.99	131.35	2.005
11	0.99	167.03	1.946
12	0.98	201.56	1.942
13	0.99	220.91	1.975
14	1.01	250.19	1.996
15	1.01	301.07	2.042
16	1.23	301.67	2.026
17	1.01	350.74	1.980
18	1.96	132.40	2.038
19	2.00	167.32	2.004
20	1.85	235.66	2.000
21	1.90	299.07	1.984
22	2.01	345.11	2.042
23	3.99	151.53	2.114
24	3.95	153.92	2.227
25	3.94	299.65	2.009
26	4.09	380.13	2.072
27	5.93	168.58	2.298
28	5.99	299.06	2.046
29	6.00	345.43	2.068
30	7.95	179.25	2.336
31	8.02	270.28	2.118
32	8.00	298.81	2.080
33	8.02	375.97	2.101
34	9.97	194.13	2.386
35	9.98	194.55	2.399
36	10.00	216.44	2.269
37	10.06	223.67	2.298
38	10.04	226.61	2.269
39	10.00	250.72	2.227
40	10.02	250.75	2.235
41	10.01	254.69	2.223
42	10.03	258.58	2.173
43	10.02	270.06	2.181
44	9.99	299.62	2.118
45	10.01	299.82	2.101
46	10.02	302.28	2.143
47	9.97	330.68	2.152
48	10.00	345.45	2.131
49	12.09	196.34	2.520
50	12.02	210.69	2.428
51	12.02	235.38	2.369
52	11.96	238.11	2.256
53	12.00	249.94	2.269
54	12.01	253.22	2.227
55	12.02	265.19	2.210
56	12.08	269.65	2.244
57	12.00	299.54	2.135
58	12.03	299.62	2.168
59	12.04	309.05	2.139
60	11.97	330.63	2.143
61	12.00	345.95	2.152
62	12.03	378.14	2.122
63	13.96	204.40	2.654
64	14.01	217.64	2.474
65	14.03	223.37	2.516
66	13.96	239.80	2.323
67	14.01	258.07	2.265
68	13.97	271.39	2.273
69	14.04	280.68	2.252
70	14.01	299.58	2.227
71	13.88	300.71	2.189
72	13.92	345.55	2.181
73	13.84	377.40	2.160
74	16.12	208.24	2.755
75	15.99	225.38	2.545
76	16.03	227.20	2.554
77	16.04	254.96	2.377
78	16.06	268.32	2.311
79	16.01	299.90	2.248
80	15.82	303.96	2.239
81	15.94	345.00	2.189
82	15.82	378.15	2.193
83	17.98	217.55	2.838
84	18.00	226.10	2.658
85	18.00	233.99	2.679
86	18.04	252.29	2.507
87	18.03	258.64	2.415
88	18.03	270.53	2.357
89	18.03	299.94	2.319
90	17.81	340.06	2.210
91	17.81	375.21	2.206
92	20.03	220.88	2.855
93	19.78	223.07	2.910
94	20.06	235.79	2.746
95	20.04	254.36	2.545
96	20.03	269.20	2.449
97	20.01	279.35	2.377
98	19.79	304.08	2.307
99	19.80	339.83	2.223
100	19.80	374.80	2.248

TABLE 12 SPECIFIC HEAT OF SUPERHEATED STEAM —KNOBLAUCH AND RAISCH

[*Z.V.D.I.*, vol. 66 (1922), no. 17, pp. 418–423. Electrical equiv.: 1 kilocal. = 4.186 Int. kilojoules]

Exp. no.	Pressure, kg. per sq. cm.	Temp., deg. cent.	C_p Int. joules, per gram per deg. cent.
1	2.00	124.82	2.093
2	7.96	247.41	2.131
3	9.99	184.10	2.529
4	14.00	247.11	2.311
5	16.00	205.23	2.834
6	18.03	280.59	2.361
7	20.12	232.14	2.830
8	20.15	245.99	2.646
9	20.11	247.13	2.600
10	20.14	280.40	2.373
11	22.13	219.91	3.282
12	22.16	231.88	2.951
13	22.09	246.47	2.742
14	22.10	247.09	2.759
15	22.05	280.36	2.440
16	22.07	280.51	2.440
17	22.06	351.62	2.248
18	24.08	225.85	3.357
19	24.15	231.66	3.114
20	24.13	247.14	2.825
21	24.15	280.16	2.516
22	26.20	229.62	3.525
23	26.18	240.90	3.059
24	26.14	247.06	2.942
25	26.13	280.83	2.558
26	26.13	351.60	2.290
27	28.15	234.16	3.550
28	28.15	234.19	3.541
29	28.13	240.80	3.236
30	28.14	246.92	3.106
31	28.18	280.59	2.625
32	30.18	238.22	3.663
33	30.13	241.39	3.391
34	30.14	247.08	3.290
35	30.13	279.97	2.713

traordinarily small except in the region near saturation at 80 to 110 kg. per sq. cm. This region is one in which the Harvard extrapolation was known in advance to be especially untrustworthy, because it can be reached by the extrapolation method in question only by boldly integrating a long series of μ values which, if they have any meaning at all, must correspond to supersaturated steam. The extraordinary agreement in other parts of the plane of the Harvard extrapolation with the smooth curves determined by the M.I.T. data is a searching and gratifying check on the mutual consistency of these two parts of the American steam-research program.

After the current temporary American chart was finished, and the corresponding tables were completely blocked out, the paper of Knoblauch and Koch arrived and a C_p diagram was immediately prepared, based wholly on American work, on which the observations of Knoblauch and Koch could be plotted for comparison. The result is shown in Fig. 11.[24] When it is remembered that these observations of Knoblauch and Koch lie largely in a region in which almost no previous experimental data of any kind were available, the agreement between the American prediction and the German observations is extraordinarily good.

Finally, we may use this same current temporary American table as a basis for comparing the observations of Havlíček and of Callendar with the body of data that has been crystallized in the table. Fig. 12 shows Callendar's 52 points of 1926 and Havlíček's points at 52 kg. per sq. cm. against the background of Keenan's table. The Havlíček points are in good agreement with the American table except at the highest temperatures,

[24] Reprinted from MECHANICAL ENGINEERING, vol. 51, no. 2, Feb., 1929, p. 129.

where they tend to lie below the tables. The Callendar points are in agreement with the tables in general trend, but lie in general about 4 B.t.u. per lb. higher than the tables would predict.

Fig. 13 shows the privately circulated group of Callendar measurements near the critical point, and some of Havlíček's points, again against the background of Keenan's table. The agreement is, on the whole, very good.

It may be mentioned that the group of Callendar points in Fig. 13 constitute the only experimental basis yet adduced for his startling suggestion that two miscible phases persist at temperatures above what is commonly regarded as the critical point. It seems to us that this group of points, while valuable, is not characterized by a high enough precision to enable any one to distinguish, by means of them, between an isothermal with a flat segment and the very slightly curved isothermal which the accepted theory would predict in this region. Furthermore the apparent existence of a true latent heat in accordance with the Callendar suggestion, and the existence of very large specific heats in this region as required by the classical critical-point theory, would be, from the experimental point of view, two pictures so nearly identical in every observable respect as to be indistinguishable. Indeed, we doubt if any possible measurements of either specific volumes or total heats and of pressures along any isothermal in this region could be expected to distinguish between these two theories. We therefore see no reason for abandoning the traditional point of view as to what happens at and near the critical point.

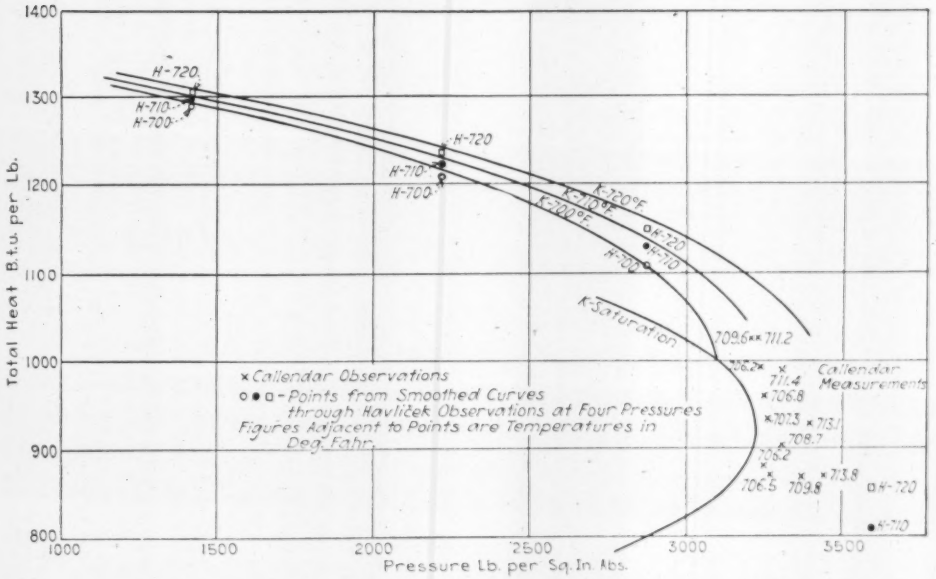


FIG. 13 CALLENDAR'S AND HAVLICEK'S TOTAL-HEAT MEASUREMENTS AT HIGH PRESSURE COMPARED WITH THE KEENAN TABLES

(The Callendar points are those on which Callendar has based his suggestion that the liquid and vapor phases persist and are distinguishable at temperatures above what is commonly regarded as the critical point. The curves are from the Keenan tables.)

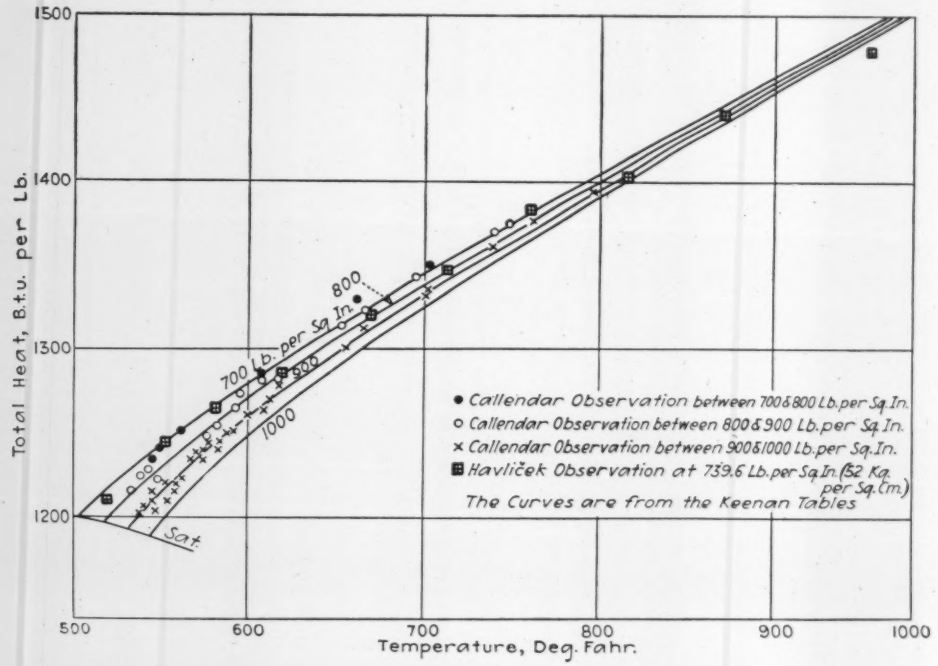


FIG. 12 CALLENDAR TOTAL-HEAT MEASUREMENTS COMPARED WITH THE HAVLICEK MEASUREMENTS AT 52 KG. PER SQ. CM. AND WITH THE KEENAN TABLES

(Callendar values obtained from chart given with Howard Lecture of Nov. 29, 1926. Havlíček values obtained from chart privately communicated. Twelve out of 52 Callendar points were obtained by the condenser method. The other 40 and the Havlíček points were obtained by throttling to atmospheric pressure.)

SUMMARY

It may be remarked, by way of a summary, that the recent experimental work on steam reviewed in this paper (*a*) covers, in one way or another, for the first time, practically the whole field up to the critical pressure, and from saturation to the highest superheats at present commercially practicable, and (*b*) shows, wherever intercomparisons have as yet been made, a most gratifying degree of consistency. There are, of course, notable gaps yet to be filled in. Among them may be mentioned the specific heat of the liquid at very high temperatures. Latent heats should also be measured at temperatures higher than Jakob has yet reached, although in this region there are already available or in sight data enough to compute latent heats up to the critical point by means of the Clapeyron equation. There is also a singular dearth of C_p measurements at low pressures and temperatures, say, below 130 deg. cent. In this region, appar-

TABLE 13 SPECIFIC HEAT OF SUPERHEATED STEAM —KNOBLAUCH AND KOCH

[*Z.V.D.I.*, vol. 72, no. 48, Dec. 1, 1928, pp. 1733–1739. Electrical equiv.: 1 kilocal. = 4.186 Int. kilojoules]

Exp. no.	Pressure, kg. per sq. cm.	Temp., deg. cent.	C_p Int. joules per gram per deg. cent.
1	19.8	332.9	2.277
2	19.9	334.8	2.260
3	19.9	335.9	2.244
4	29.9	241.6	3.353
5	29.9	246.6	3.219
6	29.9	259.3	2.968
7	29.8	283.8	2.671
8	29.8	320.1	2.419
9	29.9	353.9	2.378
10	29.9	358.4	2.382
11	29.8	386.3	2.314
12	29.9	433.9	2.327
13	29.9	437.0	2.339
14	29.9	493.2	2.344
15	40.1	252.8	3.880
16	40.1	257.3	3.805
17	40.1	263.8	3.495
18	40.1	274.0	3.261
19	40.1	288.5	2.989
20	40.1	322.7	2.650
21	40.1	371.2	2.491
22	40.1	403.7	2.412
23	40.1	436.5	2.390
24	40.1	436.8	2.390
25	40.1	494.0	2.382
26	60.2	280.3	4.626
27	60.2	283.8	4.354
28	60.1	287.5	4.160
29	60.2	301.1	3.680
30	60.1	324.6	3.156
31	60.1	334.6	3.052
32	60.2	368.0	2.742
33	60.1	369.2	2.684
34	60.2	429.0	2.533
35	60.2	437.7	2.537
36	80.0	297.6	5.672
37	80.0	300.5	5.303
38	79.9	309.7	4.701
39	79.9	326.2	3.880
40	79.9	341.5	3.466
41	80.0	375.0	3.018
42	80.0	377.5	3.030
43	80.0	421.0	2.733
44	80.0	423.7	2.751
45	100.2	314.9	6.392
46	100.2	317.9	6.388
47	100.2	318.0	5.952
48	100.2	324.5	5.668
49	100.2	335.0	4.722
50	100.2	352.5	3.951
51	100.2	376.1	3.428
52	100.2	411.9	3.031
53	100.2	410.1	3.064
54	120.1	326.9	8.234
55	120.1	328.6	7.828
56	120.1	335.4	6.488
57	120.1	342.2	5.706
58	120.0	345.1	5.542
59	120.1	352.7	5.023
60	120.1	365.9	4.295
61	120.1	389.0	3.609
62	120.1	427.6	3.110

TABLE 14 DAVIS AND KLEINSCHMIDT JOULE-THOMSON COEFFICIENTS

t, deg. cent.	p, kg. per sq. cm.	Observed μ deg. cent. per kg. per sq. cm.
125	1.125	4.801
145	1.405	3.730
	2.81	3.998
166	1.60	2.973
	1.76	3.092
	2.85	3.209
	5.62	3.264
196	1.60	2.368
	3.52	2.409
	7.04	2.557
	7.04	2.474
	7.60	2.522
	10.55	2.570
	10.55	2.490
225	1.60	1.882
	3.16	1.995
	7.04	1.978
	10.55	1.948
	14.77	1.987
	20.25	1.953
	20.25	2.001
260	1.60	1.485
	3.16	1.536
	10.55	1.549
	14.77	1.548
	15.11	1.577
	20.00	1.551
	25.30	1.545
	32.40	1.533
	39.60	1.511
300	1.70	1.163
	3.16	1.193
	8.44	1.192
	14.00	1.207
	15.00	1.197
	20.25	1.201
	32.70	1.187
347	1.60	0.932
	7.38	0.929
	15.00	0.928
	35.00	0.919

ently one of the easiest in which to work, Brinkworth's single determination stands almost alone. There is also a gap in our knowledge of C_p at high temperatures, between the highest reached by Knoblauch and the region explored with somewhat doubtful precision by means of explosion experiments. This is a region hard to work in, but important in view of the part that the water vapor formed by combustion plays in internal-combustion engines, in furnaces, and in cutting and welding torches.

Nevertheless the main outlines of a universally acceptable body of knowledge about the thermal properties of steam are beginning to emerge. It is hoped that even before this paper appears, the first steps will have been taken toward securing some sort of a workable international agreement on this important question, and that hearty cooperation will insure substantial progress in this direction in the near future.

The Wiesinger High-Pressure Locomotive

THIS locomotive has been developed by Prof. Kurt Wiesinger of the Technical College, Zurich, and built by the Swiss Locomotive Works at Winterthur. It is a 4–4–0 express locomotive of 1200 hp. The boiler, of water-tube type, is somewhat similar to the Brotan. The top drum, of seamless mild steel, preferably rolled eccentrically so as to provide thick metal to take the boiler ends, acts as a container, and the steam is taken direct from it by means of an internal horizontal pipe to the engines. The main drum and its supports are free to move on a flexible support secured to the main frames. The feedwater heated almost to boiler temperature is admitted to the lower drums. Adjacent to the main generating tubes and arranged in zigzag formation are the superheater and feedwater-heating coils.

The high efficiency of 80 per cent is claimed for the boiler. The main engine consists of two rows of six single-acting cylinders set in line, the diameter of the pistons being $7^7/_8$ in. and the stroke $11^{13}/_{16}$ in. With a 6 per cent cut-off and at 1260 r.p.m. these should develop 2000 hp. Steam at 600 lb. per sq. in. in the steam chests will, after giving off its energy passing through these cylinders, pass to the condenser, in a single stage at, say, 25 lb. per sq. in.

The valve gear is of the rotary type with ring valves specially designed to meet the requirements of such a fast-running engine. As the steam enters the cylinders on the up as well as the down stroke of the ring valves, the latter need only be driven at half the speed of the engine. The period of admission coincides with the speed of the valve, so that delayed opening is not possible. To alter the cut-off it is necessary to alter the slot of the valve, and this is done by increasing or diminishing the distance between time to turn the shaft actuating the valve motion relatively to the crankshaft of the engine.—*The Locomotive* (London), vol. 35, no. 445, Sept. 14, 1929, pp. 229–300, 2 figs.

Improvements in the Mechanical Loading of Coal Underground

LOADING coal into mine cars, which is considered as the most arduous of the miner's tasks, is largely a hand operation. Reasons for this were explained in a paper by O. G. Sharrer, presented at the semi-annual meeting of The American Society of Mechanical Engineers, Salt Lake City, Utah, and published in the July issue of MECHANICAL ENGINEERING. Some discussion of this paper is presented herewith.

While mechanical loading of coal has now passed the experimental stage, there are many developments needed to bring it into general use. Complicated designs which make parts inaccessible for convenient repairs, inspection, and maintenance appear as a weakness of present machines. Improvements to bring about simplicity of construction and ease of making repairs will help to solve this problem in underground loading.

WILLIAM WHALEY.[1] One of the first machines to be placed in operation for loading coal underground was that designed by William E. Hamilton of Columbus, Ohio. This machine would fall under Mr. Sharrer's Class 1. It had a main frame or truck, was self-propelling, and had a forward portion or jib which swung laterally so as to reach over the width of the mine room. A rear portion with a conveyor discharged into the mine car. The loading principle of this machine consisted of an endless chain running in a plane slightly inclined to the horizontal, with arms attached to the chain which pulled the coal up and conveyed it back to the rear conveyor. This machine was mechanically successful. When first installed in 1905 in a mine at Ziegler, Illinois, however, the labor situation prevented its continued operation. This particular machine was later taken over by one of the larger mining-machine companies, but has never met with any degree of commercial success, largely because in those early years the coal-mining industry was not in a mood to cooperate actively in the development and use of mechanical loaders.

About this time J. E. Jones, general manager of the Pocahontas Fuel Company, was experimenting with a machine similar in general design to the Hamilton loader. In 1907 the first Whaley shoveling machine, later known as the Myers-Whaley shovel, was designed, and the first machine was put in operation in a coal mine at Windrock, Tennessee, in 1909. This machine employed an entirely different mechanical principle, and differs from all other loading machines.

The machine consists of a main frame, on which is mounted the motor and driving mechanism, which is supported by wheels on a mine track. A swinging front end or jib carries the shoveling mechanism and a conveyor. The conveyor on the jib discharges on to a second conveyor, also mounted pivotally on the main frame. This carries the material to be loaded and discharges into the mine car. The loading element consists of a double shovel supported and driven by means of a crank, the rear end of the shovel being supported in guide ways. The mechanical principle closely resembles that of a crank and connecting rod, with the connecting rod extended beyond the crank to form the forward portion of the shovel.

This shovel is automatic and the crank rotates continuously, material being taken up by the front of the shovel, and deposited in a bucket in the shovel. The bucket is partially turned over during a portion of the stroke and deposits its load on the conveyor.

[1] General Manager, Myers-Whaley Company, Knoxville, Tenn. Mem. A.S.M.E.

The first machine built in 1909 demonstrated the correctness of the principle employed, and loaded several thousand tons of coal. The first machine sold commercially was for loading coal in West Virginia in 1911, eighteen years ago, and this machine developed a capacity of over a ton a minute, loading up to 200 tons per shift. These machines suffered, however, from the same inertia which had been encountered by the Hamilton machine and comparatively few were used in coal mines, but their use in rock and ore mines developed fairly rapidly.

These machines were limited in their application to mines having grades of not over eight per cent and having at least five feet of height. The Independent Coal & Coke Company of Salt Lake City installed one of these machines in their coal mine at Kenilworth, Utah, in 1917. Adverse grades in this mine caused the suspension of the operation of this machine after it had been in use for a year or two, but it was put back in service in March, 1927. The United States Fuel Company installed one of these machines in their coal mine at Hiawatha, Utah, in 1917, but the same difficulty was encountered with heavy grades. Quite a number of this type of machine are now in use loading coal, rock, and ore, and in tunnel work.

Another type of machine developed about eight or nine years ago was the Joy loading machine. This machine employs arms operating in a plane slightly inclined to the horizontal, and in that respect is somewhat similar to the Hamilton and Jones machines except that the Joy mechanism consists of two crank disks which operate two gathering arms. The action is automatic, and the arms operating on the inclined plane pull the coal on to a conveyor which is located between them. The first of the Joy machines was similar in general arrangement to the Hamilton, Whaley, and Jones machines in having three principal elements of a main frame mounted upon track wheels, a swinging front end, and a swinging rear-discharge conveyor. Later the Joy machine was mounted upon caterpillars, and it has been very successful.

A still later development than the Joy machine is the Goodman power shovel. The Goodman machine consists of a main frame mounted upon caterpillars and having a large shovel mounted on a swinging beam. This machine also has a jack against the roof to take the thrust of the shovel. The shovel is forced into the material, lifted, swung laterally over the mine car, and its load is pushed over the edge of the shovel by a sliding back piece. All motions of this shovel, except traveling, are effected by hydraulic power. The single motor mounted on the frame of the machine drives a pump furnishing the hydraulic pressure. This machine has met with considerable success.

Still another type is the Sullivan machine built by the Sullivan Machinery Company. This is mounted upon caterpillars, the general arrangement being somewhat similar to that of the Joy. The gathering mechanism, however, is different and consists of a wide, flat plate at the front of the machine, in the center of which is the forward end of a flight conveyor. Mounted above this plate is a rotating bar carrying picks or teeth. The bar is carried by arms from the side of the machine so that it may be raised or lowered. As this bar rotates it pulls the coal on to the wide plate and on to the conveyor.

Still another type of loading machine and one which while not built in large quantities has operated very successfully, is the Oldroyd machine. This machine is track mounted on double trucks, has a swinging front end carrying a conveyor and a loading device, a central transfer conveyor, and a swinging rear conveyor.

The loading device consists of a rotating vane with two arms rotating on a horizontal axis, and driven by chains on each side. The machine is moved forward continuously into the coal and is said to have a large capacity. It is driven by four or five motors, while the other machines which have been described are each driven by one motor only.

Most of the loading machines now on the market, especially the Joy, Sullivan, Goodman, and Myers-Whaley, are equipped, when necessary, with Government-approved permissible motors and electric apparatus for use in gaseous and dusty coal.

The following are fundamental requirements in the design of a successful underground loading machine:

1 The machine must be capable of lifting the broken rock, ore, or coal from the ground, and delivering it into the mine car at a rapid rate.

2 The entire machine must be capable of working in restricted spaces both in height and width.

3 The machine should be capable of handling lumps of broken material at least as big as two men can handle.

4 The loading element must be mounted so that it can reach from side to side and pick up the material over a considerable width from a single track.

5 The discharge end of the machine should be adjustable laterally so that the machine can operate upon sharp curves which are usually found in mines, and can load on such curves.

6 The machine should be self-propelling so that it can move from one place to another with minimum delay, under its own power.

7 As practically all mines are equipped with tracks upon which the cars for transporting materials travel, the machine should be adapted to move around on these tracks.

8 The machine should be designed so that any power available in the mine may be used for its operation.

9 The machine must have sufficient weight and strength to perform without failure the most arduous work to which it can be subjected, and the construction must be such that the machine will endure such work under any conditions with a minimum of attention and repairs.

10 The machine must be operated by one man, and be so simple in operation that the ordinary handy man can, after short instruction, operate it satisfactorily.

11 The mechanical elements involved in the design of the machine should be simple, sturdy, and accessible, so that mechanics ordinarily employed at mines can make repairs and adjustments. Parts should be standardized and interchangeable to avoid delays in supplying and fitting.

While the biggest field in mechanical loading underground in coal mines is in loading the coal, another very useful application is handling rock. Where the coal is thin, considerable rock has to be handled in taking top or bottom to secure additional height in the haulage ways and air ways. There is also considerable grading and handling of roof falls, etc.

FRANK V. HICKS.[2] It is no doubt surprising to most people unacquainted with coal mining to learn that coal loading, the most arduous task around any coal mine, is still done largely by hand. The industry has been accused of backwardness, and justly so. The first successful loading machine was placed in operation in the year 1900. The fact that for the following 22 years less than one-half of one per cent of the total coal loaded was accomplished by loading machines is quite sufficient proof of this backward tendency. Mr. Sharrer has given some of the causes that have contributed, in a measure at least, to preventing the installation of mechanical loading devices.

[2] Supervisor of Mechanical Loading, The Union Pacific Coal Co., Rock Springs, Wyo.

Previous to the year 1918 the trend in the bituminous-coal industry had been steadily upward, the average yearly increase in production amounting to 16,800,000 tons. Since that time there has been an arrested demand for bituminous coal, and in 1928 the total production was but 493 million tons, which represents but 85 per cent of the tonnage produced in 1918.

Since 1918 the annual supply of energy from all sources, coal (anthracite and bituminous), oil, natural gas, and water power has increased 13.8 per cent, oil production showing an increase of 153 per cent, and natural gas an increase of 101 per cent. Oil imports increased 55 per cent. The total supply of energy in the form of oil and gas from all sources increased 133 per cent. Water power in the same period increased 102 per cent. Coal, as previously indicated, has suffered a loss of approximately 15 per cent.

The World War, with its high prices and actual shortage of fuel supply, forced upon the consumer the necessity of fuel economies. These economies are ever becoming more manifest, with the result that today the steam locomotives on all Class 1 railroads since 1918 have decreased their consumption per thousand gross ton-miles more than 22 per cent, with the best locomotives operating with economies of approximately 60 per cent. The iron and steel industry has economized in fuel consumption approximately 15 per cent. Electric power and utilities plants have cut their consumption from approximately $3\frac{1}{2}$ lb. per kw-hr. to less than two pounds, with the best plant operating at 0.86 lb. per kw-hr. The utilization of by-products from coking plants has made further inroads into demand. Arrested growth of population, centralized heating, etc., have all combined to lessen the demand for coal.

The coal industry, accustomed for generations to an increasing demand for its product, has developed facilities for a potential production far in excess of that justified or required. This potentiality is estimated by the Bureau of Mines at 821 million tons, based upon a work year of 308 days.

This large overdevelopment, with its resultant cut-throat competition, has led to depressed prices for product, and in many localities a wage scale that is not commensurate with American ideals and standards of living. The perspective of the coal operator in these localities does not take in these ideals, and in the opinion of many he is on the way to certain destruction. Some other means of salvation must be devised.

Contrary to popular belief, the coal industry is not a dying one. Of the total consumption of energy in the United States, bituminous coal at the present time is the source of 50.3 per cent, and anthracite of 8.1 per cent, making a total for coal of 58.4 per cent. Domestic oil constitutes 21.4 per cent, imported oil 1.3 per cent, natural gas 5.8 per cent, and present developed water power the rather insignificant amount of 6.3 per cent. The large increase in the production and consumption of oil in the United States does not for the most part represent a displacement of coal. The water power and natural gas are in direct competition with coal, but much of the fuel oil and practically all of the refined products of petroleum are used for purposes that raw coal could not meet.

If and when the nation is confronted with a depleted oil supply, the lower grades of coal, much of which is easily mined through stripping operations, will, according to an unprejudiced authority, take precedence over the oil shales as a future possible source of fuel oil.

In its present dilemma, based upon observation of results obtained by the company by which the writer is employed, it appears that mechanical loading of coal affords a means of relief and at least a partial solution of the problems confronting the coal industry. As previously stated, the introduction of coal-loading machinery has been slow. Previous to 1923 no record was made of this tonnage in the United States; however, beginning with 1923, the record to date has been as follows:

Year	Tons
1923	1,880,000
1924	3,496,000
1925	6,148,000
1926	10,022,000
1927	14,559,000
1928	21,559,000

The above figures do not include coal from stripping operations, which in 1928 amounted to approximately 20,000,000 tons. Production from this source has held fairly uniform since 1923.

Mechanical loading has had its greatest growth in the localities where the wage scale is relatively high, as shown by the following:

	Per cent of total output loaded mechanically
Wyoming	41.3
Indiana	24.0
Utah	18.3
Montana	18.3
Illinois	13.3
Virginia	6.4
Alabama	3.6
Pennsylvania	2.2
West Virginia	1.7
Kentucky	1.0
United States	4.5

Mechanical loading is at least a partial solution of the ills of the coal industry. Results obtained by the Union Pacific Coal Company during the years 1923–1928, inclusive, show what is possible through mechanical loading.

1 There has been a reduction in the number of employees, exclusive of officials, from 3034 in 1923 to 1838 in 1928, the latter representing 60.7 per cent of the former.

2 The annual output for the period 1923–1928 fluctuated but little. This of course is due entirely to railroad demand.

3 The number of operating mines was reduced from 19 to 11.

4 Mechanically loaded coal in 1923 totaled 107,693 tons or 3.2 per cent of total. In 1928 mechanically loaded coal was 1,591,578 tons, or 51.3 per cent of total.

5 Mine cost in 1928 represented but 75.7 per cent of the cost of 1923, with but 51.3 per cent mechanical loading.

6 Annual earnings of employees other than officials and supervisory force increased from approximately $1700 in 1923 to $2263 in 1928.

7 The total capital expenditures over the above period for mechanical loaders was $429,392.68. The undepreciated investment in loading equipment as of January 1, 1929, was $259,232.97.

8 The investment in loading equipment for an annual production of 100,000 tons is approximately $30,000. The company has been exceedingly fortunate in that every purchase of loading equipment has justified the investment.

With the introduction of mechanical loading in the mines of the Union Pacific Coal Company, the president of the company, Eugene McAuliffe, announced the policy that no men would be discharged to make places for loading equipment. As the labor turnover had, prior to 1923, exceeded 100 per cent, men that left the employment of the company of their own choice were slowly supplanted by machines. In this way no hardship was worked upon the miners in the employment of the company.

Mechanization of the coal industry will materially reduce the number of miners actively engaged, leaving many to be absorbed by other industries; however, those that remain with the industry will inevitably receive a better wage, and the industry as a whole will find itself in more tranquil waters.

The demand for coal is seasonal. By a proper selection and application of loading machines, coupled with intelligent planning and foresight on the part of those who have charge of operations, it is possible to arrange so that during the off-peak period machines may be placed largely on development work, in which case the tonnage per unit is not so great, and then when the demand is heavy they are placed into work where a larger production per unit may be obtained.

Of the various types of loaders enumerated in Mr. Sharrer's paper, all have reached a fair state of perfection. There is still a very prevalent feeling of skepticism in the minds of many coal operators as to the possibilities for coal-loading machinery. The stock scheme in the past has been to have the manufacturers guarantee the successful operation of the machine in a given property. No manufacturer of loading equipment can afford to do this. Mechanical loading is contingent upon too many factors that enter into every-day underground operation to justify the manufacturers in assuming such an obligation. The various types of machines have been proved. It is now up to the coal man to make the selection of equipment suitable to conditions, and then give the machine the opportunity to prove itself by giving it every advantage and insisting upon the cooperation of the entire operating force.

While the operating principle of most of the leading types of loading machines is sound, still from a construction and assembly viewpoint the present-day underground loading machine is in about the same state of development that the automobile was 18 or 20 years ago. The duty to be performed by mine-loading equipment is unusually severe, still maintenance charges are entirely too high, often running as high as 8 to 10 cents per ton. This unusually large maintenance cost often offsets a possible saving or profit. The most glaring defect is in the selection of materials of construction and assembly, parts often being so inaccessible that hours of labor are required in dismantling to make adjustments, or what should be minor repairs. When the various loading devices now in use have received the proportionate amount of thought and talent by mechanical engineers that countless other mechanical devices have, there will be much better machines, and mechanical loading in the mines of this country will increase much more rapidly. Trouble and grief in the maintenance of loading machines have discouraged many a willing but faint-hearted coal operator, and his first attempt at mechanization has ended in failure and financial loss.

In spite of the failures and discouragements attendant upon mine mechanization, the coal industry of America is awakening, and the next five or ten years will see startling changes. There are 7011 bituminous coal mines in the United States, producing annually from 500 to 550 million tons of coal. During June, 1929, there were but 200 graduate mining students from all of the colleges and universities of this country teaching mining, a very small percentage of whom will follow coal mining.

The fundamentals of all engineering training are essentially the same. But with mining, more than any other branch of the profession, is the school, college, or university unable to turn out a finished product. By contact and experience only can the technique, if such it may be called, of underground-mine operation be acquired.

Upon this premise, with the increasing tendency toward mechanization of coal-mine operation, coal mining offers a multitude of opportunities for the young graduate in mechanical engineering, as at the present time at least the demand for engineers is in excess of the supply.

The type of structural steel, in the form of plate and of flat bar, giving the best tensile properties is that containing 0.3 per cent of carbon with about 1.3 per cent of manganese and 0.9 per cent of silicon. A small amount of nickel increases the ductility, but at least 3 per cent is required to produce high-elastic-limit steel.—J. A. Jones before the Iron and Steel Institute, London, September 11, 1929.

Operation and Control of Boiler-Feedwater Purification Systems

Routine Tests of Value in the Control of Boiler Feedwater and Concentrated Boiler Waters—The Cost of Laboratory Control and Its Relative Value

By S. T. POWELL,[1] BALTIMORE, MD.

DURING recent years there has been a decided trend toward higher steam pressures and temperatures and increased ratings of boilers. (See Fig. 1.) Five years ago steam pressures of 250 to 300 lb. were considered high. From 1926 to date there have been built or are now in the course of construction many boilers which are operating at 400 lb. pressure or higher. Five of these installations have been designed to operate at pressures in excess of 1000 lb. and one at 1800 lb. These conditions are the result of a natural sequence of engineering development, striving after greater economy in steam generation. The necessity for good feedwater under such conditions is evident, and has focused attention to these problems.

Many engineers recognize the importance of good feedwater with respect to the operation of high-pressure boilers, but fail to recognize the importance of the problem as it affects the operation of boilers at lower temperatures and pressures. The losses occurring in the generation of steam either for power or process uses due to bad feedwater and to inadequate control of boiler-water concentrations are enormous. A full realization of these losses by the management of public-utility corporations or private industries would result in more detailed attention to this portion of their plants.

Much has been written concerning methods of analysis of feedwater, but little information is available to indicate the specific importance of such data in the control of steam stations, and few data have been published concerning the economic value of such control. It is largely for this reason that many companies have not been impressed with the necessity or the value of this work. The saving resulting from accurate control of the feedwater systems by routine chemical analyses can be easily demonstrated, and plants where accurate cost records have been kept can verify these statements. So much depends on the constancy of service from the steam station that any neglect or inefficient control of this portion of the plant must sooner or later be reflected in reduced efficiency of the entire plant. This holds true not only in central-station practice and in the gas industry, but in all industrial activity.

Heavy losses have been sustained during the past two years in some of the largest industries in this country from bad feedwater conditions which could have been prevented had the steam stations been under proper analytical control.

During the year a large national organization has sustained a financial loss running into six figures by failure to recognize the importance of chemical control of the feedwater system. Within the past month a boiler failure has been reported which could have been avoided by routine chemical analyses of the concentrated boiler waters. Such analytical data would have indicated the corrective feedwater treatment required. It would hardly seem necessary to direct attention to these problems were it not for the fact that failures are occurring, many of which could be avoided.

Efficient operation of boiler-feedwater systems can best be obtained by the establishment of a laboratory where routine analyses of the untreated and treated water can be made. The size of the laboratory and the force necessary to carry on the work will be influenced by a number of conditions. The most important factors are the capacity and rating of the boilers, the type of water treatment, and the quality of the water supply. To condition the feedwater properly at a high-pressure steam station operating at high ratings, the plant should be under a full-time trained chemist with one or more assistants. The

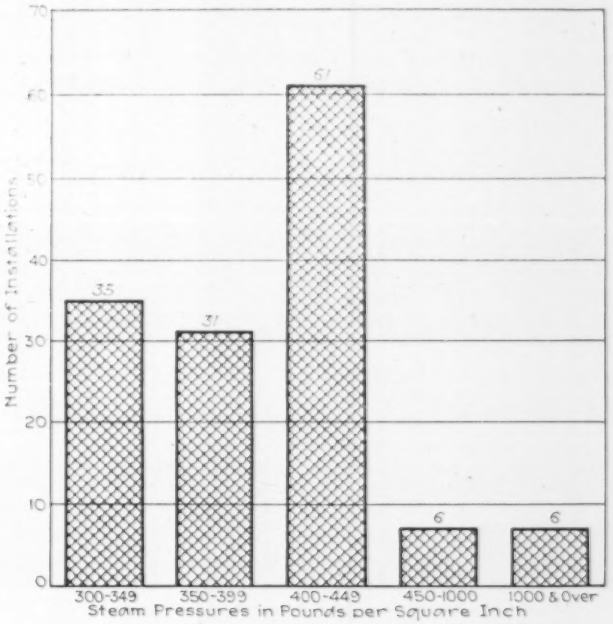


FIG. 1. RECENT BOILER INSTALLATIONS INDICATING THE TREND TOWARD HIGHER STEAM PRESSURES

(From data compiled by the author and from figures presented by P. W. Swain before the Philadelphia Section of the A.S.M.E., March 26, 1929.)

chemist should report to the chief engineer or superintendent, and should be given the necessary authority for the control of the system. He should likewise be held responsible for the elimination of trouble due to bad water conditions. Relatively smaller plants may be adequately controlled by one trained man, but he should be provided with such non-technical help as may be required for the collection of samples and for other control duties.

The cost involved in the establishment of laboratory equipment will depend upon the amount and character of work involved. The necessary apparatus and the supply for work of this kind is much less expensive than is ordinarily estimated, and frequently an exaggerated idea of these costs is responsible for the failure to establish a control laboratory. For a cost of from $100 to $200, sufficient equipment and supplies can be purchased to carry on all the necessary tests for adequate con-

[1] Consulting Chemical Engineer.

trol measures in a small plant. Under ordinary conditions a fairly complete water-testing laboratory sufficient for all routine tests in a large steam station can be established at from $1500 to $2000. This of course would not include building or other laboratory structural costs.

It is extremely difficult to generalize concerning the frequency of testing feedwater and to itemize the specific tests that should be made. Considered broadly, concentrated boiler water should be tested not less frequently than once a day. Elaborate treating systems, especially those where acid-correction treatment is employed, will require testing much more frequently.

Adequate records should be maintained as to the condition of the water-treating equipment and appurtenant apparatus. Many failures resulting from bad feedwater may be traced directly to lax inspection of the feedwater purification equipment.

Method of Analysis Applicable to Feedwater

There is no single method of feedwater treatment that is applicable for all conditions. Each plant should be designed and operated with specific reference to the local conditions. Since there is no universal treatment there can be no universal method of control, and the tests to be made of the treated feedwater and concentrated boiler water will depend upon the conditioning system employed. For this reason it is difficult to prescribe any set of tests that will meet all requirements. There are, however, certain routine tests which are of value and from which efficient control of the systems may be effected. Tests which in most cases will be of value are listed in Table 1.

TABLE 1 ROUTINE TESTS FOR THE CONTROL OF BOILER FEEDWATER AND CONCENTRATED BOILER WATERS

Raw water	Treated water	Concentrated boiler water
Temperature	Temperature	Temperature
Total solids	Total solids	Total solids
Suspended solids	Suspended solids	Suspended solids
Total alkalinity—carbonate, bicarbonate, and hydrate alkalinity	Total alkalinity—carbonate, bicarbonate, and hydrate alkalinity	Total alkalinity—carbonate, bicarbonate, and hydrate alkalinity
Chlorides	Chlorides	Chlorides
Sulphates	Sulphates	Sulphates
Free CO_2	Free CO_2	Free CO_2
Hydrogen-ion concentration	Dissolved oxygen	Phosphates
	Hydrogen-ion concentration	Specific gravity
		Hydrogen-ion concentration

Tests for chlorides, total alkalinity, and sulphates are simple tests to make, and a daily record of these constituents in concentrated boiler water will be of great assistance in supplying the essential data for adequate control. Detailed methods of analysis are given herein which have been prepared to assist the non-technical operator in making these tests.[2]

Test for Total Alkalinity

The alkalinity of a water indicates the presence of certain salts in solution, which have the power to neutralize acids. The alkaline salts may be present in a number of different forms. The ones usually present in boiler feedwaters are known as carbonates, bicarbonates, and hydrates. One or two of these forms of alkalinity may be present in a water, or there may be a change from one form to another during chemical treatment or under the influence of heat.

It is desirable for the plant engineer to know not only the amount of total alkalinity of his boiler water, but also the amount of each kind of alkalinity. He should know what parts of the alkalinity in the water tested are present as carbonate, bicarbonate, and hydrate alkalinity. These tests are comparatively simple and may be readily made with a fair degree of accuracy by any intelligent operator.

Total alkalinity, as the term implies, means the total amount of all forms of alkaline salts in solution in the water. Place 100 cc. (cubic centimeters) of the water[3] to be tested in a porcelain evaporating dish having a capacity of 150 to 200 cc. Add about 0.1 cc. (2 to 4 drops) of methyl orange indicator, which is referred to later as M, and stir with a glass rod. The color of the water after adding the indicator will be yellow if the water is alkaline; if it turns red, the water under test is acid. When the water is alkaline, add one-fiftieth normal sulphuric acid (marked $N/50$ H_2SO_4) drop by drop from a glass burette that is graduated to read in tenths of cubic centimeters, stirring the water after each addition of acid until it changes from yellow to a faint pink; then read the burette and determine how much acid was used to bring about this change. Each cubic centimeter of acid used is equivalent to 10 parts per million of alkalinity.

Example: Suppose 100 cc. of water requires 4.2 cc. of acid, then $4.2 \times 10 = 42$ parts per million of total alkalinity.

Test for Carbonate, Bicarbonate, and Hydrate Alkalinity

To determine carbonate, bicarbonate, and hydrate alkalinity a second test must be made, which is carried on as follows:

Place 100 cc. of the water to be tested in a porcelain evaporating dish, and add a few drops of phenolphthalein indicator, which is referred to later as P. If the color of the water remains white after adding the indicator P, all the total alkalinity read in the test with the M indicator is present as bicarbonates. If the water turns red after the addition of the phenolphthalein indicator, add $N/50$ H_2SO_4 as in the test for total alkalinity and determine how much acid is required to change the color from red back to white.

Example: Suppose 2.7 cc. were required to bring about this change, then the P alkalinity would be $2.7 \times 10 = 27$ parts per million.

The various forms of alkalinity may be calculated from the formulas given in Table 2.

TABLE 2 FORMULAS FOR COMPUTING THE VARIOUS FORMS OF ALKALINITY PRESENT

	Bicarbonates	Carbonates	Hydrates
$P = 0$	M	0	0
P less than $\frac{1}{2} M$	$M - 2P$	$2P$	0
$P = \frac{1}{2} M$	0	$2P$	0
P greater than $\frac{1}{2} M$	0	$2(M - P)$	$2P - M$
$P = M$	0	0	M

Example: Suppose M alkalinity = 42 parts per million, and P alkalinity = 27 parts per million. One-half of 42 = 21. The P alkalinity is greater than $\frac{1}{2} M$, therefore there is no bicarbonate alkalinity and the alkalinity is caused by carbonates and hydrates which, according to the figures given in Table 2, would be $2(M - P) = 2(42 - 27) = 30$ parts per million of carbonate alkalinity, and $2P - M = 2 \times 27 - 42 = 12$ parts per million of hydrate alkalinity.

Test for Chlorides

The term "chlorides" is used to express the combination of chlorine with other elements forming salts that are comparatively stable and not easily broken up under ordinary conditions. The term "chlorides" is to be distinguished from "chlorine," such as liquid chlorine used extensively for the sterilization of public water supplies. The chlorides commonly present in water are sodium chloride (common salt), magnesium chloride, and potassium chloride.

The test for chlorides is performed in the following manner: Place 100 cc. of water to be tested in a 150-cc. porcelain evaporat-

[2] Detailed methods of analysis will be found in "The Standard Methods of Water and Sewage Analysis," published jointly by The American Public Health Association and The American Water Works Association. Also in "Boiler Feed Water Purification," by S. T. Powell. McGraw-Hill Book Company.

[3] The amount of water employed for this or other tests may be reduced, but the proper factor should be used to be comparable with the calculation given.

ing dish and add 1 cc. of potassium chromate indicator. If the water is acid, the sample should be neutralized. The color of the water will be yellow. Add the standard silver nitrate solution from a burette drop by drop until the color of the water changes from yellow to a faint red. When this change takes place, determine how much of the silver nitrate solution has been used, multiply the number of cubic centimeters of solution by 10, and the result will be the chlorides present in water expressed in parts per million.

Example: Amount of silver nitrate solution used, 10.8 cc.; $10.8 \times 10 = 108$ parts per million of chlorides.

TEST FOR DISSOLVED OXYGEN

The presence of oxygen in water used for boiler feed is objectionable, since it increases the corrosive properties of the supply. It is essential in steam-station operation that the dissolved oxygen content of the feedwater be kept as low as possible. In order to control the dissolved oxygen, tests should be made at frequent intervals. This test is not particularly difficult and may be carried out by an operator who has not had special training in chemistry, provided the sample is taken carefully and the test is made with strict adherence to the instructions. The solutions required are as follows:

1 Manganous Sulphate: Dissolve 430 g. (grams) of manganous sulphate in 1 liter of distilled water.

2 Alkaline Potassium Iodide: Dissolve 700 g. of potassium hydrate and 150 g. of potassium iodide in distilled water and dilute the solution to 1 liter.

3 Hydrochloric Acid: Concentrated (specific gravity 1.18 to 1.19).

4 Sodium Thiosulphate: One-fortieth normal (N/40). (This solution should be carefully prepared and checked by a chemist, as should the other normal solutions.)

5 Starch Solution: Dissolve about 5 g. of Litner's soluble starch in 50 cc. of distilled water to make a thin paste and then pour into 200 cc. of boiling distilled water and continue boiling for 4 to 5 min. When cold add a few drops of chloroform and keep this solution in a glass-stoppered bottle in a dark, cool place. Starch solution does not keep well and should be made up fresh every week or ten days.

The bottle in which the sample is collected should be a glass-stoppered tincture bottle of good quality and have a capacity of from 250 to 270 cc. The sample of water to be tested should be passed into the bottle through a glass or rubber tube extending to the bottom. Where the dissolved oxygen is to be determined from hot-water samples, the water should be cooled to about 70 deg. fahr. by passing through a copper cooling coil prior to discharging into the sample bottle. The water should pass through the bottle, slowly flowing for at least 5 min., and the quantity wasted should be not less than five times the capacity of the bottle. The sampling tube should be withdrawn from the bottle before the water is shut off and the glass stopper then replaced.

Remove the glass stopper from the bottle and add 1 cc. of manganous sulphate solution and 3 cc. of alkaline potassium iodide, using separate pipettes for each solution. These solutions should be discharged at the bottom of the bottle. After the addition of the chemicals the stopper is replaced and the bottle shaken and permitted to stand 5 min. A brown precipitate will settle. The stopper is again removed and 2 cc. of hydrochloric acid are added, the stopper replaced, and the bottle again shaken. By the addition of the acid the precipitate will be dissolved. (It is necessary that all precipitate dissolve.) The procedure up to this point should be carried out as quickly as possible, but the remaining portion of the test may be delayed for several hours if necessary without introducing an error into the determination.

Two hundred cubic centimeters of the treated sample are then transferred to a flask of 500 cc. capacity and standard sodium thiosulphate solution (N/40) is added from a burette drop by drop until the yellow color of the water has been nearly removed. When this point is reached, $^1/_2$ cc. of the starch solution is added. The color of the sample will be changed from yellow to blue by the addition of the starch. The thiosulphate solution is again added to the sample drop by drop until the blue color is completely removed and the sample is colorless.

Read the burette and determine the number of cubic centimeters of thiosulphate solution used in the test. This amount will be the dissolved oxygen present in the water expressed in parts per million by weight. To convert the dissolved oxygen from parts per million to cubic centimeters per liter, multiply parts per million by 0.698.

Example: Number of cubic centimeters of thiosulphate used in test, 8.2; dissolved oxygen in parts per million, 8.2; ∴ dissolved oxygen in cubic centimeters per liter $= 8.2 \times 0.698 = 5.72$.

The standard gravimetric method for the determination of sulphates is not applicable for routine work in determining the sulphate content of concentrated boiler water, principally because the method is time consuming and the accuracy which it affords is not ordinarily required for plant control.

The Parr turbidimeter method for sulphates is sufficiently accurate for determining the sulphates in boiler waters, and has the added advantage that it is fairly rapid and requires no special technique. The method consists of measuring the turbidity produced by precipitating the sulphates by means of barium chloride in a slightly acidified solution. The finely divided barium precipitate is measured by limiting the depth of solution through which a standard light can be detected. The apparatus is standardized against solutions of sulphates of known strength.

A somewhat similar method has been developed in which the sulphates are precipitated by barium chloride and the concentrated turbid solution is diluted by distilled water until a standard light becomes visible. The degree of dilution is a measure of the amount of sulphates present in the original sample.

Although these methods are of value on account of the rapidity with which they can be made, there are some objections to them, and errors are introduced which may result in high or low readings of the actual sulphate content of the water. The fineness of the precipitate depends upon the acidity of the solution, also on the amount of the barium chloride used and the rate at which it is applied; the temperature of the solution and concentration of other salts in solution also have a marked effect upon the condition of the precipitated barium sulphate. These conditions should be given careful consideration, and the accuracy of the test should be checked from time to time by gravimetric determinations. Considered broadly, however, the turbidity method for routine determination of sulphates may be used to advantage.

The determination of carbonate and hydrate alkalinity of concentrated boiler waters can be made by the ordinary titrimetric method. The method is reliable, however, only in the absence of appreciable amounts of organic matter when the water is relatively clear. When concentrated boiler waters contain an appreciable amount of organic matter in solution or suspension or where the water is turbid or highly colored, these determinations should be made by the Winkler method. The procedure for this method is given herewith in detail,[4] since it is not generally used for this purpose.

[4] Reproduced from Treadwell, Sixth Edition, revised, vol. 2, p. 485.

DETERMINATION OF ALKALI CARBONATE AND HYDROXIDE IN THE PRESENCE OF ONE ANOTHER—METHOD OF C. WINKLER

Of the many methods which have been proposed for this determination, that of Winkler is the best.

In one portion determine the total amount of alkali present by titration with acid, using methyl orange as an indicator, and determine the hydroxide in a second portion as follows: To the solution add an excess of barium chloride solution; the following reactions take place:

$$Na_2CO_3 + BaCl_2 = 2NaCl + BaCO_3 \text{ (insoluble)}$$
$$2NaOH + BaCl_2 = 2NaCl + Ba(OH)_2 \text{ (soluble)}$$

Add phenolphthalein and titrate slowly with hydrochloric acid with constant stirring; decolorization is effected as soon as the hydroxide is neutralized and before any barium carbonate is dissolved. The amount of acid used corresponds to the amount of hydroxide originally present.

Example:

1. 20 ml.(Na_2CO_3 + NaOH) require T ml. 0.1 N acid for Na_2CO_3 + NaOH;

2. 20 ml.(Na_2CO_3 + NaOH) require t ml. 0.1 N acid for NaOH alone, so that

20 ml.(Na_2CO_3 + NaOH) require $(T - t)$ ml. 0.1 N acid for Na_2CO_3; 20 ml. of the solution therefore contain $t \times 0.004001$ g. NaOH, and $(T - t) \times 0.005300$ g. Na_2CO_3.

Remark. It has been proposed to add an excess of barium chloride solution to the mixture of alkali carbonate and hydroxide in a measuring flask, then dilute to the mark, thoroughly mix, filter through a dry filter, and take an aliquot part of the filtrate for the titration. This method, however, will only give accurate results when the water used for the dilution is absolutely free from carbon dioxide, and this will be the case only when it is previously boiled with a current of air free from carbon dioxide passing through it. Further, no attention is paid to the volume occupied by the precipitated barium carbonate, and in the case of a large amount of the latter a considerable error is introduced. The method of Winkler does not have these disadvantages. Care must be taken, however, with regard to the addition of the hydrochloric acid in the titration; unless it is added very slowly some of the barium carbonate will be acted upon before the end-point is reached.

A number of attempts have been made to employ sensitive hydrometers to determine the specific gravity of concentrated boiler waters as a means for controlling the concentration of solids and to indicate the condition of the water in the boiler under actual operating conditions. Most of these hydrometers have been of little value, since they have not been sufficiently sensitive. Recently, however, a number of companies have supplied hydrometers for this purpose which, in the absence of other control, may be of value. Most of them, however, have a limited field of usefulness.

A special design of sensitive hydrometer[5] has recently been put upon the market which is being used extensively for rapid analyses of concentrated boiler water. In addition to indicating the specific gravity of the water, the total solids and the sodium sulphate content of the water can be determined. This is accomplished by simple calculation of the specific gravity, alkalinity, and chlorides previously determined in the water.

The conditioning of feedwater by the use of phosphates is now practiced widely, since such treatment has certain specific value. The use of phosphates under some conditions will inhibit the formation of hard scale and is of value in the prevention of embrittlement of boiler steel. The necessity of a reliable test for these constituents in concentrated boiler water is important where phosphate treatment is used. Comparative tests of the various methods have indicated that for ease in manipulation and reliability the method recommended by Staub is most satisfactory.[6]

[5] Designed by J. A. Holmes, National Aluminate Corporation.

[6] A full description for this method will be found in MECHANICAL ENGINEERING, vol. 51 (1929), p. 26.

The determination of the phosphate is dependent on the fact that molybdenum present as phosphomolybdic acid may be reduced in the presence of an excess of molybdic acid. The reducing agent used is hydroquinone. If hydroquinone is added to an acid solution of molybdic acid, no phosphate being present, the solution will be colorless when treated with alkaline sulphite, but if phosphate is present, phosphomolybdic acid is formed and reduced, giving a blue color. As small an amount as 5 p.p.m. of phosphate gives a distinct blue color in this test.

COST OF LABORATORY CONTROL AND ITS RELATIVE VALUE

It is difficult to generalize in reference to the specific cost of chemical analyses of boiler-feedwater treatment systems, since this work is usually conducted by plant analysts and the accounting systems do not segregate the analyst's time for this specific work, which may only be a part of his general duties. In the majority of plants, however, the cost of laboratory control of boiler-water conditioning can be fully justified by the

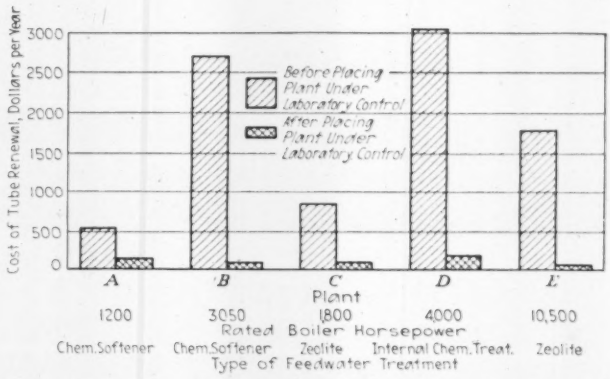


FIG. 2 REDUCTION IN BOILER-TUBE RENEWALS FOR ONE YEAR AT FIVE PLANTS RESULTING FROM ROUTINE CONTROL BY CHEMICAL LABORATORY

resulting improvement in operation. As an illustration of these facts, the results obtained at a number of stations are given in the several charts which are included in this paper. Attention is directed first to the reduction in the cost of tube renewals in the five plants before and after the feedwater conditioning was controlled by routine analyses. In each of these plants the water was treated by an approved system of feedwater conditioning. In every case there was a marked saving in tube renewals immediately after accurate chemical control was inaugurated. Prior to placing the plants under the chemical laboratory, the systems were operated by the watch engineers or firemen. Some determinations were made of the feedwater, but there was no certainty of the accuracy of the analyses, and there existed a complete lack of intelligent interpretation. Directly after accurate chemical control was inaugurated, a marked improvement was noted as indicated in Fig. 2.

Frequently there is a gross waste of chemicals in the operation of water-softening plants resulting from failure to regulate the chemical reagents required to soften the waters. The hardness of many surface waters fluctuates greatly and requires frequent adjustment of chemicals employed in softening the supplies. Such adjustments can only be made intelligently by analyses of the untreated and treated water. More important still is the interpretation of the analytical data, which should be done by a trained chemist. Justification of the cost of laboratory control is clearly apparent in many installations.

The results of a typical case are reported graphically in Fig. 3. Occasionally there may be an increase in cost of chemical

when accurate chemical control is started, but where such increase in operation results it indicates that in previous control inadequate amounts of reagents were employed to effect complete softening.

Rarely is a water-softening plant operated continuously at maximum efficiency if the control is left to the boiler-room force, without supervision by the laboratory. A typical instance of the possible improvement that can be effected by control of the system by trained workers is illustrated in results of such control shown in Fig. 4.

A cost analysis of chemical control of feedwater systems to

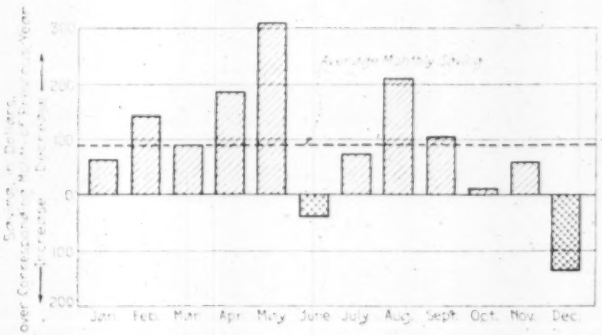


FIG. 3 REDUCTION IN COST OF TREATMENT IN A BOILER-FEEDWATER SOFTENING PLANT RESULTING FROM PLACING SYSTEM UNDER LABORATORY CONTROL
(Chemical softener; rated capacity, 400,000 gal. daily.)

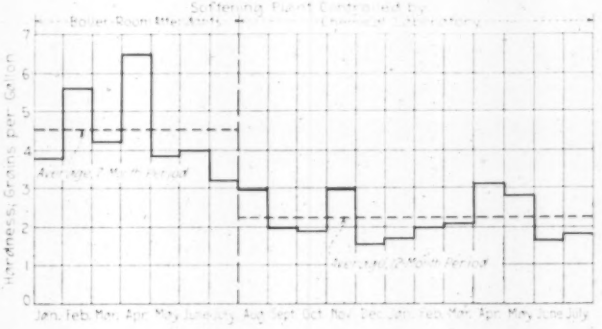


FIG. 4 IMPROVEMENT IN QUALITY OF BOILER FEEDWATER, AS MEASURED BY THE RESIDUAL HARDNESS IN THE SOFTENED WATER, RESULTING FROM PLACING OPERATION OF SYSTEM UNDER CONTROL OF CHEMICAL LABORATORY

allocate the specific value of such control is difficult and influenced by many local factors. Cost data, therefore, may be misleading unless interpreted with respect to the specific set of conditions.

Fig. 5 shows for one particular company the cost of laboratory control in comparison with the total cost of treatment. Here the plant is under the control of a chemical engineer and two assistant analysts whose duties are confined exclusively to the control of the boiler feedwater, combustion, and other problems peculiar to a modern steam station. These figures demonstrate clearly that the cost of chemical control is fully warranted, taking into consideration the small percentage of this cost in comparison with that of maintenance of the system. Detailed control as carried out in the plant in question further demonstrates beyond any measure of doubt that this operation is warranted.

The installation has an installed capacity of approximately 10,000 boiler horsepower. The developed horsepower, however, is frequently double this rate. The plant is subject to sudden changes in rating, a condition which is frequently the cause of serious priming and foaming. The boiler-feed make-up is approximately 75 per cent and the quality of the feedwater fluctuates over a wide range, since the source of the supply is a surface water subject to serious industrial contamination. Notwithstanding these widely fluctuating variables, the plant has operated for more than two years with no tube losses and no serious difficulties from wet steam. In addition, the plant is entirely free from scale, and only very minor corrosion has been noted. Most of this was during the early stages of operation, and occurred in the steel-tube economizers. It would have been impossible to produce these results under the exacting conditions of operation and the quality of the feedwater without placing the feedwater system under the most careful analytical control.

Priming and foaming of boiler water are influenced by a number of factors and constitute a perplexing problem in the operation of steam boilers. Much can be done to control the carry-over of water from boilers by control of the concentration of solids in boiled water. This can be accomplished most

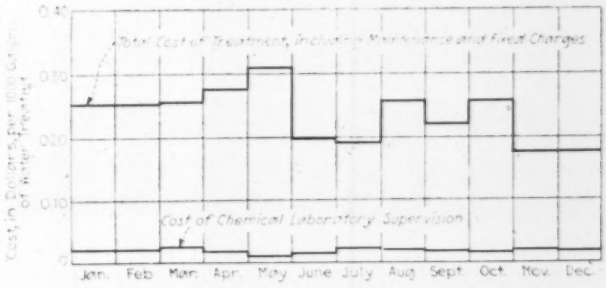


FIG. 5 COST OF CONTROL OF FEEDWATER SOFTENING BY CHEMICAL-LABORATORY SUPERVISION IN COMPARISON WITH TOTAL COST OF OPERATION
(Chemical softener; capacity, 600,000 gal. daily.)

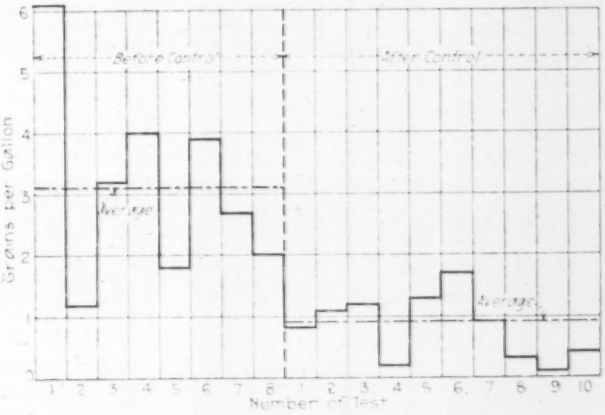


FIG. 6 REDUCTION IN PRIMING AND FOAMING OF BOILERS RESULTING FROM CONTROL OF BOILER BLOWDOWN BY ROUTINE CHEMICAL ANALYSES OF THE CONCENTRATED BOILER WATER AS MEASURED BY TOTAL SOLIDS IN THE CONDENSED STEAM

satisfactorily by regulating the blowdown cycle by analyses of the water at regular intervals. A recent investigation of priming and foaming boilers clearly demonstrated the very great value of this method of control. The improvement in the quality of the steam as indicated by the moisture content before and after chemical control is indicated in Fig. 6.

It is impossible to allocate the saving in general operation and maintenance resulting from dry steam, but that a marked

saving does result from these improvements cannot be questioned.

CONCLUSIONS

Corrosion and embrittlement of boiler steel, priming and foaming of boiler waters, and the formation of dense scale on heating surfaces may only be controlled by properly designed water-conditioning appliances and constant supervision by intelligent operators. To accomplish the desired results in these respects requires frequent analyses of the raw and treated feedwater and of the concentrated boiler waters. The analytical data must also be interpreted intelligently by a trained operator, since the mere collection and recording of analytical figures will be of little value unless they are employed for the intelligent control of the system.

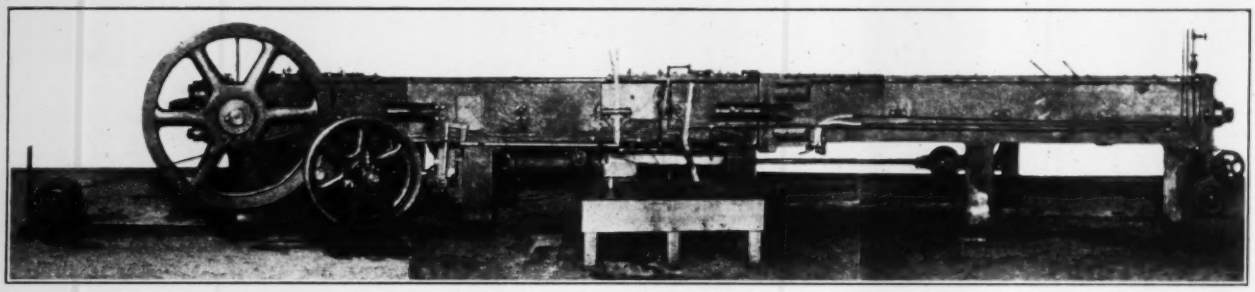
At the present time there is a lack of fundamental knowledge concerning the reaction and counter-reaction that may occur under the influence of the very high pressures and temperatures now used. For this reason the control of feedwater systems should receive as detailed study and attention as is required in the operation and maintenance of any other portion of the plant.

Possibly an explanation of the conditions as they exist is due to the general impression that feedwater conditioning is relatively unimportant in comparison with the perplexing problems in general plant control. Fortunately, considerable publicity has been given to the glaring failures resulting from poor feedwater conditioning, and more and more attention is being drawn to the matter of effecting economies in steam generation.

Through the activities of the various technical associations, valuable information on this subject is being released which may shortly impress upon those responsible for steam generation the enormous importance of this subject. These data will be of little value, however, unless engineers come to a full realization of the necessity for analytical control, since feedwater-conditioning appliances may only effect the desired improvement in the feedwater supply when such processes are intelligently and conscientiously controlled by proper analytical tests.

Improved Method of Making Thin-Walled Tubing for Metal Bellows

BY WILLIAM S. LYHNE,[1] KNOXVILLE, TENN.



TUBE-DRAWING MACHINE USED FOR MAKING THIN-WALLED TUBING

METAL bellows have a great many applications. Their manufacture requires a thin-wall tubing with wall thickness of from 0.006 in. to 0.009 in. Many methods are used for making the tubing. That used by the Fulton Sylphon Company includes a method and apparatus by which successive portions of a tube are intermittently forced between relatively moving punch-and-die elements, the tube being restrained against movement during the alternating periods when the punch or die is being moved into cooperative relation with a succeeding portion of the tube.

The machine is divided into two sections having the die head in the center. It is about 30 ft. long. One section consists of the punch end, similar to a horizontal press with an 8-in. stroke. The other section consists of a variation of a draw bench, and the two are exactly synchronized in their movement.

To work the machine, a tube is taken that has the bottom spun partly over, or if it has a bottom, a hole is pierced in it. Air raises the punch and its long rod to an angle of 45 deg. A "tail" is inserted and the tube is put on the punch until it reaches the bottom, which causes the tail to project out of the opening of the tube. The punch is then dropped to a horizontal position in line with the die. The head containing the die is then moved up so the tube fits snugly into the die with the tail projecting through. Next, the draw-bench feature is moved up until the jaws in its head snap over the tail with which the tube is drawn. The punch then moves forward for a distance of 8 in., as does the drawn bench in a synchronized movement with the punch, the tube thus receiving a push and a pull at the same time. When the drawing apparatus has reached its maximum movement for the stroke a cam drops into the ratchet, which prevents the drawing head or the tube from moving back as the punch is withdrawn. These movements are repeated until the full length of the tube has passed through the die, when it is removed by the drawing head hitting a release valve which opens the jaws grasping the tail. All machine parts then automatically return to their starting position.

Practically any metal can be drawn by this method, and the tubes come out with a superior finish, the thickness of the wall being very uniform for the full length. Tubes made by this method also have the physical properties of cup and drawn tubes, and can be used under conditions impossible to expect from an extruded tube. While these tubes can be made in any size, present equipment is only made for sizes ranging in diameter from 1 in. to 6 in. and in lengths up to 10 ft. All sizes can be drawn to a wall thickness as low as 0.004 in.

[1] Manager, Tubing Division, The Fulton Sylphon Co., Knoxville, Tenn.

Presented at the Knoxville Meeting of the A.S.M.E., Knoxville, Tenn., March 21 to 23, 1929.

Spherical Containers for Transporting Gas Under High Pressure

Transportation of Helium Under 2000 Lb. Pressure in Multiple-Sphere Tank Cars—Results of Tests of a Large, Thick-Walled Spherical Pressure Vessel Designed and Constructed Especially for This Purpose

THE idea of using spherical containers for the transportation of gas under high pressure was conceived by the A. O. Smith Corporation, and a tank car, based on this idea, was developed for the U. S. Navy. This new type of car, Fig. 1, carries six spherical containers capable of transporting 210,000 cu. ft. of free helium at a pressure of 2000 lb. per sq. in.

The spherical container has the inherent advantage of being approximately 25 per cent lighter than a cylindrical container of the same capacity. It also is much simpler in design and construction if made of two formed heads welded together. Inasmuch as this construction has not been provided for in the regulations of the A.R.A. and the I.C.C., it was necessary to obtain the approval of these bodies before this type of car could be used. Arrangements were therefore made to conduct a series of tests on a specimen sphere in the presence of representatives of the Tank Car Committee, the Bureau of Explosives, and other interested parties.

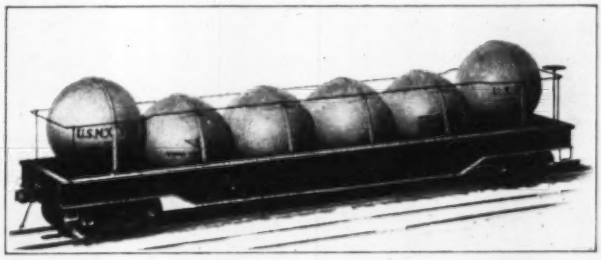


FIG. 1 MULTIPLE-SPHERE TANK CAR FOR TRANSPORTING HELIUM UNDER 2000 LB. PRESSURE

(Capacity, 210,000 cu. ft. of free helium. Car designed and developed for the U. S. Navy, Bureau of Aeronautics.)

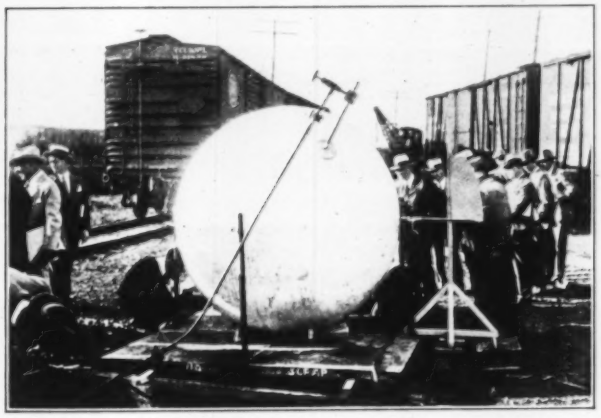


FIG. 2 SHOWING GENERAL APPEARANCE OF TEST SPHERE

(Sphere mounted for destruction test, with Ames dials and expansion meter in position.)

From a report covering tests made for the A. O. Smith Corporation, Milwaukee, Wis., September 6–10, 1929, by R. Furrer, T. McLean Jasper, and H. H. Needham, respectively, Chief Engineer, Director of Research, and Sales Engineer of the corporation.

It was felt that these tests would not only demonstrate the safety of this method of construction, but would also supply actual data not before available on the design of spherical containers. So far as is known, tests of this nature have never been conducted before on large, thick-walled spherical vessels.

DESCRIPTION OF SPHERE

Fig. 2 shows the general appearance of the sphere, and Fig. 3 represents a cross-section showing the construction and giving dimensions. The sphere was made of two plates $1^1/_2$ in. thick, each formed to the shape of a hemisphere. These hemispheres were electrically welded together to form a sphere. The outside circumference was 237.5 in. at the weld, and 237 in. at right angles thereto. The calculated average outside diameters of these circles were 75.6 in. and 75.48 in., respectively, and the actual average measured diameters were 75.25 in. and 75.25 in. The maximum inside diameter would therefore be 72.25 in.

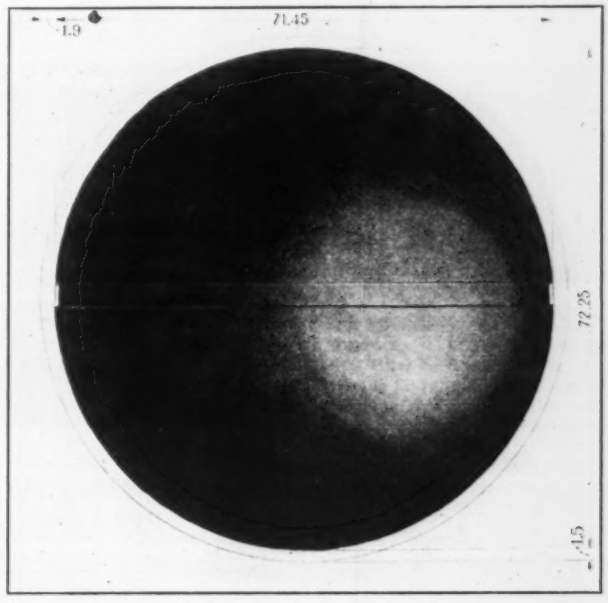


FIG. 3 DRAWING SHOWING DIMENSIONS OF TEST SPHERE AS BUILT

(Note that apex of each hemisphere is somewhat thinner than the rim.)

It is of interest to note that the thickness of the vessel wall at its minimum section was 1.5 in. and at its maximum section 1.9 in., the increase in thickness over that of the original plate thickness being due to the forming of the hemispheres from flat plates. The vessel was very true to shape in every particular, and, although it weighed 8300 lb., it could be rolled along easily on a flat surface.

The material used in the construction of the sphere was purchased under the corporation's regular specifications for thick-walled pressure vessels. These cover a steel of 0.20–0.30 per cent

carbon content, having a minimum ultimate strength of 55,000 lb. per sq. in. and a minimum yield point of one-half this value.

The actual material as rolled gave the following test values:

Ultimate strength.....	60,250 lb. per sq. in.
Yield point.....	31,700 lb. per sq. in.
Elongation in 8 in.....	22 per cent

After fabrication, the sphere was heated in an automatically controlled furnace to a temperature of 1200 deg. fahr. and left to soak for four hours at this temperature. This treatment, in all probability, reduced the strength of the metal 2000 to 3000 lb. per sq. in. That the strength is reduced by such a treatment has been proved by many tests on thick plates placed with vessels being stress-relieved at this temperature.

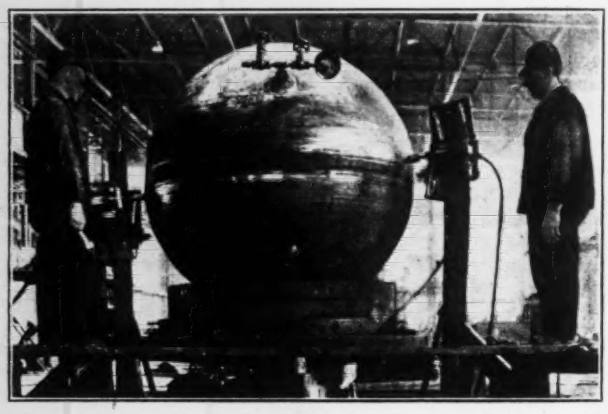


FIG. 4 SPHERE AS MOUNTED FOR VIBRATION-FATIGUE TEST
(Four air hammers struck 20,000,000 blows while sphere was under 1250 lb. per sq. in. hydrostatic pressure. Note peened area of the surface.)

Following the stress-relieving operation, the sphere was subjected to a hydrostatic test which involved:

1 A repeated-stress test, during which the pressure was varied a number of times between limits corresponding to a stress in the material of 45 and 60 per cent of its yield point.

2 A hammer test with the sphere under a pressure producing a stress in the metal of 60 per cent of its yield point. During this test the welded joint was hammered at 1-ft. intervals with full-swing blows of sledges having a weight equal to 10 per cent of the weight of 1 sq. ft. of the vessel wall.

3 A high-pressure test of one hour's duration in which the sphere was under a pressure producing a stress in the metal equivalent to 75 per cent of the yield point.

THE VIBRATION-FATIGUE TEST

After completion of the foregoing tests, the sphere was subjected to the vibration-fatigue test, the purpose of which was to simulate the vibration which would be experienced by the spherical containers in service on a tank car. This test, however, was much more severe on the metal than anything it would actually experience during years of transportation service.

The sphere was put under a hydrostatic pressure of 1250 lb. per sq. in., which stressed the metal to 50 per cent of its yield point. It was mounted on a turntable, revolving at the rate of of $^1/_8$ r.p.m. Four Thor S-2 air hammers were placed so as to strike the sphere at opposite points, and the hammering covered an area extending 13 in. each side of the welded joint. The air hammers were provided with bronze heads about 2 in. in diameter. The test was run for 75 consecutive hours, during which time twenty million (20,000,000) blows were struck, each representing 4 to 5 ft-lb. of energy. About sixty hammer heads were rendered useless during the test. The effect of the hammering on the shell is clearly visible in Fig. 4.

During the test the pressure gradually increased to 1360 lb. per sq. in., corresponding to a stress of 54 per cent of the yield point. This was probably due to increased temperature of the water from the energy transmitted by the air hammers.

THE IMPACT TEST

It was desired to reproduce as closely as possible a train wreck so as to study the performance of the sphere under such abuse. Therefore, following the vibration test, the water was emptied out of the sphere and replaced with air at a pressure of 1200 lb. per sq. in., stressing the metal to 48 per cent of its yield point.

The sphere was then mounted on a flat car in a manner similar to the method designed for the proposed tank car and strapped down. Two heavy steel cylinders, each weighing 14,500 lb., were also mounted on the car, one immediately ahead of the sphere and one behind it. The car was then pushed off the end of a trestle while moving at the rate of about 20 miles per hour—a sheer drop of some 25 ft.—Fig. 5 shows it in mid-air just after being pushed off the trestle. It is to be noted that placing the sphere between two cylinders created a condition worse than if two other spheres were used, since there would be a tendency for the cylinders to stay with the sphere in falling down the slope, while spheres would have a tendency to deflect sideways.

The rear cylinder rode the sphere down the slope for some distance after the two had been catapulted from the car. All three bounded through the hollow at the bottom of the slope, the sphere finally coming to rest 113 ft. from the end of the trestle. It showed a number of marks and abrasions where it had hit rocks or had been struck by the two cylinders.

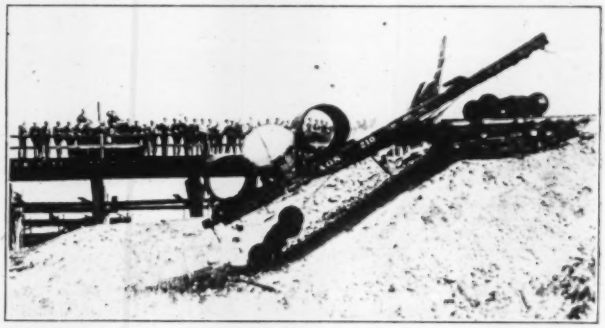


FIG. 5 TEST OF SPHERE INCORPORATING TRAIN-WRECK CONDITIONS
(Car in mid-air, having dropped both trucks; otherwise loading is intact.)

This test was not only spectacular but gave the sphere at least as severe punishment as would be experienced in a real train wreck. Following inspection by those present, the air pressure was relieved and the sphere retrieved to be prepared for the test to destruction.

THE DESTRUCTION TEST

In filling the vessel with water for this test, extreme care was taken to eliminate all free air from the vessel and piping. A scale and tank were arranged so that water pumped into the sphere or discharged from the sphere could be accurately weighed.

Fig. 2 shows the sphere arranged for the test. Three of the Ames dial gages can be seen mounted on the posts and also the expansion indicator.

In carrying out the test the pressure in the vessel was first brought to 1250 lb. per sq. in. It was then lowered to 1000 lb. per sq. in., again increased to 1250, lowered to 1000, and once more increased to 1250 lb. per sq. in. This last value represents a stress of 14,500 lb. per sq. in. in the steel. At this pressure it was then hammered with 6-lb. sledges over the entire weld.

The pressure was then reduced to zero and readings taken so

that the weight of any water later pumped into the sphere or discharged from it could be determined. Following this the pressure was raised to 2000 lb., corresponding to a stress of 24,000 lb. per sq. in. It was found that 60 lb. of water had been forced into the sphere in reaching this pressure.

After the pressure was relieved and the discharge water weighed, it was found that 58 lb. of water had been ejected from the sphere during the pressure drop from 2000 lb. per sq. in. to zero. This means that the sphere had slightly increased in size, equivalent to the volume of 2 lb. of water.

Readings were also taken on the Ames dial gages to provide a check on the permanent deformation of the sphere. These readings (see Table 1) also showed very little change.

TABLE 1 AMES DIAL READINGS AT 2000 LB. PER SQ. IN.

Dial no.	Readings in thousandths of an inch: Before applying pressure	At 2000 lb. per sq. in.	After reducing pressure to zero
1	0	29.5	1.0
2	0	21.2	3.5
3	0	9.8	0.5
4	0	10.0	—1.5
Average	0	17.6	0.9[a]

[a] This value represents the average permanent deformation under a pressure of 2000 lb. per sq. in.

NOTE: Dials 1 and 3 were opposite each other and 90 deg. from the weld. Dials 2 and 4 were opposite each other and located near the weld.

TABLE 2 AMES DIAL READINGS AT 2500 LB. PER SQ. IN.

Dial no.	Readings in thousandths of an inch: Before applying pressure	At 2500 lb. per sq. in.	After reducing pressure to zero
1	0	116.0	86.0
2	0	35.5	15.5
3	0	6.5	—2.8
4	0	11.0	—3.0
Average	0	42.5	24.0

The pressure was now raised to 2500 lb. per sq. in., corresponding to a stress of 30,200 lb. per sq. in. This is approximately the yield point of the material as received from the steel mill. The gages indicated some yielding as shown in Table 2.

The pressure was then gradually raised until a temporary shutdown was necessitated by excessive leakage around the screwed-in plug for a pipe connection, caused by expansion of the vessel wall. This leak made it impossible to increase the pressure to the point of destruction.

During the shutdown, the maximum periphery of the sphere was measured to determine the expansion. The circumference was found to be 252 in. at right angles to the weld. This is equivalent to an outside mean diameter of 80.21 in. and an inside mean diameter of 77.21 in. The sphere had therefore increased about 5 in. in diameter.

As soon as the leaky plug had been calked, a new chart was put in the recording pressure gage, and the pressure gradually raised to the point of failure.

The sphere failed at an average pressure of 4466 lb. per sq. in. This figure is the average of readings on three calibrated pressure gages, which showed 4400, 4500, and 4500 lb. per sq. in., respectively.

In no case did failure occur in or adjacent to the weld. The vessel burst into nine pieces, which scattered in various directions. The distances to the fragments ranged from 14 ft. to 53 ft. One view of the assembled fragments of the sphere is shown in Fig. 6.

CALCULATIONS FROM DATA OBTAINED

For calculating the stresses in a sphere the correct formula to use in Lamé's: namely, $S = 0.5P(b^3 + 2a^3)/(b^3 - a^3)$, in which S = stress, P = pressure, a = inside diameter, and b = outside diameter.

The pressure at which yielding started was approximately 2500 lb. per sq. in. Using the above formula, the corresponding stress is found to be 30,200 lb. per sq. in., which closely agrees with the yield point of the material.

In the same manner it is found that the stress at which final failure occurred was 57,000 lb. per sq. in. This considers the increased diameter of the vessel at failure, but not the decreased thickness of the plate. The ultimate strength, as determined above, also agrees with that of the original material when allowance is made for the reduction in strength due to the stress-relieving operation as explained earlier.

The representatives of the Tank Car Committee, witnessing the tests on the sphere, specified that at 2000 lb. per sq. in. pressure "permanent volumetric expansion must not exceed 10 per cent of total volumetric expansion at test pressure." (2000 lb. pressure corresponds to a stress of 80 per cent of the yield point.)

The total quantity of water absorbed in the vessel, due to a test pressure of 2000 lb. per sq. in., was 60 lb. as stated earlier.

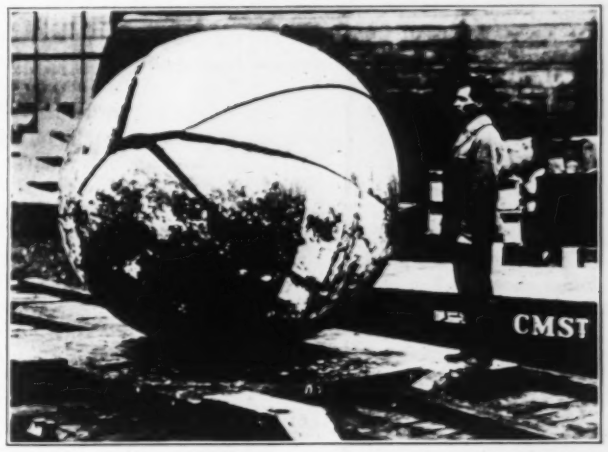


FIG. 6 ASSEMBLY OF SPHERE FROM FRAGMENTS RESULTING FROM DESTRUCTION TEST
(Note that fractures are perpendicular to weld.)

The quantity remaining after pressure had been released was 2 lb., also as stated. The permanent volumetric expansion was therefore $3\frac{1}{2}$ per cent.

The expansion was also indicated by the change in diameter as obtained from the Ames dial gages placed on posts as shown in Fig. 2. The various readings taken are given in Table 1 and record deformation in thousandths of an inch.

These readings showed a very small permanent deformation after the sphere had been subjected to a pressure of 2000 lb. per sq. in. The permanent deformation was only $^{0.9}/_{17.6} \times 100 = 5$ per cent of the total deformation while under pressure.

The permanent deformation indicated by these readings shows that at a pressure of 2500 lb. per sq. in. the metal had entered the region of its yield point.

In no case did failure occur in or adjacent to the weld. In nearly every instance the fracture was perpendicular to the weld (see Fig. 6).

From the foregoing test results it is concluded that a vessel of spherical shape conforms to the elastic theory so far as design is concerned.

It is further concluded that it is possible to build vessels of this shape so that the full strength of the steel can be utilized.

It was proved that the failure did not occur in the weld.

Mathematically it is known that of all shapes a sphere requires the least material to envelop a given volume, and it is therefore the most logical shape of container for the economical transportation of gases.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

A New Airplane Tire

THE Goodyear Tire and Rubber Co. has placed on the market an airplane tire claimed to be of radically new design. It is essentially a superballoon tire, being of great thickness when compared to its diameter and carrying a low air pressure. It was developed by the company in cooperation with A. J. Mussleman. It requires no wheel upon which it is to be mounted, i.e., the casing is fitted directly to the hub. Brakes can be included as part of the hub without annulling any of the streamline advantages of the equipment, but with slight increase of weight. Exhaustive tests have been conducted with this tire for several months, and it is said that the tire in spite of its rather cross-sectional area creates less air resistance than ordinary types due to its better streamlining.

One of the standard sizes is 22 × 10 in., taking the place of the familiar 30 × 5-in. aircraft tire. This tire, when inflated to 20 lb. pressure, is designed to sustain a static load of 1600 lb. Under these conditions the area of contact with the ground is 80 sq. in. as compared to 32 sq. in. for the 30 × 5-in. casing. Thus the new tire has about two and one-half times as much surface in contact. (*Aviation*, vol. 27, no. 7, Aug. 17, 1929, pp. 357, 1 fig., *d*)

The Dornier DO-X

ACCORDING to the newspapers, this plane has flown for one hour at a speed of 100 miles per hour with 169 persons on board. The following information as to its design is now available.

The hull is built on the general lines of a glider. The bows are of rather V-shaped section, flat at the bottom. This ends in a step at about four-tenths of the hull's 131.4 ft. overall length. From the step a short keel starts, and ends further down in a small rudder for navigation, behind which the boat's bottom has a very flat V-form tapering toward the tail.

Inside the hull there are three decks, each with ample head room, and subdivided by several watertight bulkheads. The lowest deck holds the fuel tanks, hose equipment, stores, goods, etc.

The middle deck is the main one and is reserved entirely for passengers. It is 66 ft. long without kitchen, and, dependent on the desires of the transport company, may be provided with rooms for any accommodation, special entertainment rooms, or sleeping rooms. It of course may be appointed in any fashion to meet the demands of the public it serves. For use in long-distance flights the rear section of the fuselage may also be separated from the passenger cabins by a special partition so that it may serve as accommodation for a substitute-crew shift.

The third deck is built on the order of a large cabin. The forward end, fitted with large all-vision windows, forms the pilot's compartment. Directly back of it is the navigation room, which also serves for the commander and his first mate. Then follows the engineer's room; he, with four mechanics, is responsible for the technical detail of the boat and its motors. From this room start the gangways leading right and left into the wings and to the motors above them. These gangways also hold the gasoline and oil lines, which may be kept constantly under observation. In the engineer's room is also a complete set of gages for the control of all motors. It also contains an auxiliary motor which drives a dynamo to supply current for lighting the ship and for running the many indicators and other instruments.

The last compartment of the third deck holds the wireless room. (John H. D. Blanke in *Aeronautics*, vol. 5, no. 4, Oct., 1929, pp. 42–43, illus., *d*)

The Heinkel K-2 Catapult and the Water Sail

THE North German Lloyd liner *Bremen* has been equipped with a catapult.

This catapult, which has been designed and built by the German firm of aircraft constructors, Ernst Heinkel Flugzeugwerke G.m.b.h., is used to launch an H.E. 12 Heinkel low-wing monoplane (500-hp. Pratt and Whitney Hornet engine). This seaplane is being used to deliver mail and customs papers ahead of the ship.

The Heinkel catapult as fitted to the *Bremen* consists of a skid or launching trolley accelerated over a launching way about 60 ft. long. The skid is operated by compressed air. The catapult is mounted on the top deck of the *Bremen* between the two funnels. The turntable on which it is mounted allows the launching way to be swung through 90 deg. on either side of the ship's course.

The launching way is a light angle-iron structure 20 m. (60 ft. 7 in.) long. On the top surface of this structure, which is plated to form a platform, are the rails, which appear to be angle irons bolted to the sides.

The skid or launching trolley is built of high-grade material highly stressed to keep the weight as low as possible. The skid travels on four shoes and is pulled forward by a cable passing over a return pulley at the nose of the launching way.

Two additional cables run aft from the skid to a drum at the starting end of the launching way. These cables, besides serving for testing purposes, also appear to operate the brakes. The skid is brought to a standstill in a distance of 3 m. (9 ft. 10 in.).

The operating mechanism consists of a cylinder and piston. This piston has a stroke equal to one-sixth of the accelerating distance on the launching way, and is forced out by compressed air from the ship's normal supply.

The cable after passing over the pulley at the nose of the lauching way passes over a fixed pulley at the inner end of the structure. From here the cable is wound several times alternately around pulleys on the piston and pulleys fixed to the structure. When the piston moves outward, more cable is needed to span the distance between the fixed pulley and those on the piston. This has the effect of dragging the skid forward at many times the speed of the piston.

The ropes that run aft to the braking apparatus can also be used to rotate a flywheel, which acts as an indicator that the catapult is operating correctly.

The maximum acceleration produced by the catapult is not over 3 *g*, and the flying-off speed is given as 110 km. per hr. (68 m.p.h.). The maximum weight of the skid complete with machine in place is 3500 kg. (7730 lb.).

So far all attempts to use seaplanes in conjunction with steam-

ships have been either with specially prepared runways or catapult launching devices. The latter method postulates the use of a crane to pick up the seaplane from the water on its return.

A long runway is not practicable on a liner and a catapult is expensive. In addition, if a catapult be used, the ship must be stopped to pick the seaplane up from the water—and fast mail steamers must not stop.

A method for launching and picking up seaplanes which is used when the vessel is under way and has the important advantage of low initial cost, is known in Germany as the "Kiwullsche Stausegel"—or the water sail designed by Dipl. Ing. Kiwull.

The water sail is an expanse of canvas about 30 m. (98 ft.) long and 10 m. (32 ft. 9 in.) wide, with spreader booms on the under side. One end of this canvas runway is attached to the deck over the stern of the steamer, and the other ends in a kind of drogue (or sea anchor) made of wide-mesh netting. This end is attached to the ship by tow ropes.

The action of the drogue is to cause the water to roll in over the end of the drogue, thus making it easy for a seaplane to taxi behind the steamer, and run on to the trailing runway. Once on the runway the floats are attached to skids, and the whole machine is hauled up the inclined canvas slope—which is held taut by the pull of the drogue.

The process may be reversed for launching. The Norddeutsche Lloyd Steamship Company are making extensive trials of this apparatus, which has been fitted experimentally to their local pleasure ship *Roland* and also to their steamship *Lützow*. (*The Aeroplane*, vol. 37, no. 10, Sept. 4, 1929, pp. 653–654, 3 figs., *d*)

ENGINEERING MATERIALS

Eternit Pipe

ETERNIT consists of about 80 per cent cement and 20 per cent asbestos fiber. The two materials are carefully mixed with addition of water. When ready they are placed in a dewatering machine, equipped with a bronze cylindrical sieve. This machine is described in detail in the original article.

Pipe out of this material is now being manufactured on a considerable scale in Italy—principally in Genoa—where there are large developments in the way of hydraulic works and water-supply systems, and where metal pipe of domestic origin is not available. The manufacture of the material is peculiar. It is first formed into the shape of strip. This is then wound around a mandrel equivalent to the core of a pipe in thin concentric layers, which are then subjected to pressure in hydraulically driven pressure rolls. This hydraulic pressure is subject to control and increases with the increase of thickness of the pipe wall. It not only forms the pipe but helps to squeeze out such water as may be left. The original article describes a method of connecting two pipe lengths in which rubber packing is used. Data are given from tests on the various properties of the pipe. (Dr. of Technology Fritz Emperger in *Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*, vol. 81, nos. 35 and 36, Aug. 30, 1929, pp. 355–357, 7 figs., *d*)

Beryllium

THIS is an extensive review of a book entitled "Beryllium-Arbeiten," published in 1929 in Berlin. The book is a symposium of information on beryllium and its alloys. It gives a history of beryllium, describes methods of production, and sets forth the true properties and compositions of beryllium alloys.

Direct electrolytic production of alloys of beryllium with the heavy metals has also been effected. Copper was first tried, and it was found that longer rods of copper-beryllium or nickel-beryllium alloys could be produced, without interrupting the process, than was the case in the production of pure beryllium, in which the electrical resistance of the rod produced soon increases to a point where the process becomes uneconomical.

Two methods for the direct production of beryllium–heavy-metal alloys by electrolysis are described. The alloys with high beryllium contents are best made from melts containing BeF_2 with the crucible bottom as anode, so that a heavy-metal fluoride forms on the bottom and acts anodically. From the electrolyte so formed, the heavy metal and beryllium are deposited together. In this process the heavy metal is added as powder to the metal, and sinks to the bottom.

In the second process, a cathode of the heavy metal is employed instead of the usual water-cooled type. The beryllium deposited on the cathode takes up some of the heavy metal, and the method is suitable for the production of alloys with lower percentages of beryllium, which are subsequently remelted.

It has also been shown to be possible to deposit beryllium on copper, iron, aluminum, and light alloys from baths containing an alkali fluoride and beryllium fluoride in the molten condition. By choosing a suitable bath temperature, and by subsequent tempering, it is possible to produce coatings in the form of beryllium alloys, thus effecting a novel type of case-hardening. (First part of a review by T. H. Turner in *The Metal Industry* (London), vol. 35, no. 10, Sept. 6, 1929, pp. 230–232, *g*)

FOUNDRY

The Ford Method of Core Making for Ingot Molds

WITH characteristic defiance of convention, Ford through his foundry department has developed an original method for making these castings. They are molded horizontally and cast vertically. The ingot is circular in cross-section and is fluted longitudinally. The flutes are comparatively wide and shallow, therefore the core drops readily from a metal core box split longitudinally on a center line.

The metal core box is designed to form two half-cores and is mounted on a jolt, ram, roll-over machine. A cast-iron skeleton arbor is employed to reinforce each half-core, and the sand is shoveled into the box from a pile at the rear. After the sand is rammed, a considerable amount is scooped from the center to shorten the drying period and incidentally produce a core that will crush more readily during the contracting period of the casting. Also an appreciable amount of sand and binder is saved in this manner.

Perforated aluminum plates, strongly ribbed on the back and planed to a flat surface on the face, receive the cores from the core box and support them during the green and drying periods. They are loaded in tiers on the core-oven cars.

In the manufacture of crankcase and barrels the body core is made in two equal parts. The cores are formed in metal core boxes and a length of perforated steel pipe $1^3/_4$ in. in diameter at one end and tapering down to $1^1/_4$ in. extends through each core and through the body of sand forming the crankcase and coreprint.

In the original method each of these reinforcing pipes was located on a pin provided for the purpose in the bottom of the core box. Sand was shoveled and rammed around it by a man armed with a rammer. Satisfactory cores were made in this manner, but too many men and too many core boxes were required and they occupied too much precious space.

Experiments in jolting the cores did not show favorable results. A sand-throwing machine made by Beardsley & Piper, Chicago, was installed to carry on the job. It answered the purpose in every respect, with the single exception that the sand did not seem to grip the pipe properly.

Then one day a mute, inglorious Milton unknown to fame stepped forward and said, "Why not reverse the usual process? Instead of trying to ram the sand around the pipe, why not adopt the machine-shop trick of forcing the pipe through a slightly smaller opening in the completed core in the same manner that a shaft is forced into the hub of a wheel?"

The idea was adopted, tried out experimentally, and has proved successful. Instead of a hard exterior and a soft center, the cores are now hard in the center and soft on the outside. The difference in density of course is only slight, but the pipe is gripped firmly and supports the core rigidly during the green and drying periods. (Pat Dwyer in *The Foundry*, vol. 57, no. 18, Sept. 15, 1929, pp. 772–776 and 784, 8 figs., *d*)

FUELS AND FIRING (See also Power-Plant Engineering: Lignite Power Stations in Germany: Power from Wood Refuse)

Relationship Between Calorific Value and Other Characteristics of Residual Fuel Oils and Cracked Residuums

PRACTICALLY all the data published in literature deal with straight-run fuel oils of ordinary distillation. The present paper deals with residuum from cracking stills. It begins by giving previously established formulas, from which it would appear that there is a straight-line relationship between the gravity and the calorific value in B.t.u. per lb. of oil. (The A.P.I. and not the Baumé scale is generally used in refinery practice.) Among other things, the paper discusses the relation between the carbon and hydrogen contents of an oil and calorific value, the calculation of net heat value for fuel oil and cracked residuum, and the effect of origin of crude oil on calorific value. As to the latter, there does not seem to be any definite relationship between the source of the fuel oil and the calorific value, the latter being purely a function of the gravity.

Among the conclusions arrived at the following may be cited:

A definite correlation between the A.P.I. gravity of straight-run fuel oils and cracked residuums and the B.t.u. value per pound has been established. This relationship is a straight-line function.

Knowing the A.P.I. gravity of either the fuel oil (cracking stock) or the cracked residuum, whether the latter be of the flashed or normal type, the B.t.u. value per pound or per gallon of oil can be calculated from the following equations:

B.t.u. per lb. of straight-run dry fuel oil

$$= 17{,}010 + (90 \times \text{deg. A.P.I.}) \quad (a)$$

B.t.u. per lb. of dry cracked residuum

$$= 17{,}645 + (54 \times \text{deg. A.P.I.}) \quad (b)$$

The calorific value per gallon is determined by multiplying the calculated calorific value by the weight of a gallon of the fuel oil or residuum.

The calculated values for the dry oil are accurate to within 30 B.t.u. of the values determined experimentally by precision calorimetric methods. These values are also in agreement with results of other experimenters and check fairly closely with those obtained from the average formula derived from all the formulas found in the literature. The lower the A.P.I. gravity of the fuel oil or residuum, and consequently the cheaper the oil, the lower will be the B.t.u. value per pound but the higher the B.t.u. value per gallon. The latter unit is the usual one by which such fuels are purchased.

The net calorific value was calculated for several straight-run fuel oils and the two residuums produced from them. These values are about 1200 B.t.u. per lb. less than the observed or gross calorific values as the result of correction for the latent heat of vaporization of water.

The volatility of the cracked residuums is slightly greater than that of the straight-run fuel oil, but in no case is there enough material within the boiling range of gasoline to cause any marked variation in the B.t.u. value of the fuel on the basis of a pound or a gallon. (W. F. Faragher, J. C. Morrell, and J. L. Essex, Universal Oil Products Co., Chicago, Ill., in *Industrial and Engineering Chemistry*, vol. 21, no. 10, Oct., 1929, pp. 933–941, including 9 literary references, 6 figs., *e*)

Coal-Washing Investigations

THIS bulletin presents the results of an investigation of the washing characteristics of bituminous coals from many of the important coal-producing fields of the Eastern and Central States. The washing characteristics of a few coals from the Western States are also given. A summary of the scope of the work and the principal conclusions drawn therefrom will be set forth.

The advantages of clean coal over raw coal and the effect of impurities in coal on its utilization are discussed.

The relation of the structure of the coal bed and the manner of occurrence and physical and chemical form of the impurities in it to the washability of coal is described.

A systematic method of examining and testing the washability of a coal is described, and several methods for estimating the efficiency of the results of washing tests are given. One method of estimating the efficiency that is used throughout the report and is recommended to others is an application of the general engineering efficiency formula, the ratio of output to input, to coal washing.

By this method the yield of coal obtained by float-and-sink tests is compared with the yield of coal of the same ash content obtained by washing. The ratio of these two yields is the efficiency.

The construction of a satisfactory washing or cleaning plant should be based upon some or all of the following steps, depending upon local conditions and the information at hand: (1) Measurement and sampling of the coal bed to find the nature and distribution of the impurities, and the character of the different benches of the bed; (2) observation of the methods of mining, especially the practice of breaking down and loading the coal; (3) collection of large tipple samples representing at least several days' operation of the mine; (4) laboratory examination of tipple samples, including chemical analyses, screening tests, crushing tests, complete specific-gravity analyses by the float-and-sink method, and intensive washing trials with laboratory-size or full-size equipment, preferably the latter; (5) comparison of the results on an efficiency basis and the preparation of a flow sheet using the system of treatment best adapted to the coal and operation.

The coals found in various parts of the United States vary greatly in composition with respect to specific gravity and the physical forms of the impurities which they contain, consequently they vary in washing characteristics and in the method of treatment required.

Any coal may be considered easy or difficult to wash, depending upon the proportion which is near in specific gravity to that at which a separation must be made to give a washed product of the required ash content. The proportion of material of such character at any given specific gravity for the different coals is indicated by the relative slopes of the yield–specific-gravity curves.

The complexity of the washing operation and refinements required for a given separation ordinarily increase as the specific gravity corresponding to the point of separation becomes lower, both because of the small differences in specific gravity between the material to be recovered and rejected and because of a

normal increase in the proportion of particles near in specific gravity to the point of separation. It follows that a washery will be more difficult to control if the separation required corresponds to the steep portion of the curve, and that the easiest separation may be made in the flat portion of the curve, although this portion does not always correspond to the requirements at a particular mine.

The two most important impurities in coal, ash, and sulphur, are not always associated in equal degree in the same specific-gravity fraction of the raw coal, hence the reduction of ash and reduction of sulphur are often separate and distinct problems.

Reduction of ash depends primarily upon the relative proportions, average specific gravities, and ash contents of the low-, intermediate-, and high-specific-gravity fractions. For example, the Elkhorn coal (not the bony bench) discussed in the original article has 63.7 per cent under 1.30 specific gravity which contains only 2 per cent of ash, a relatively small amount of the intermediate-gravity fraction, and 9.4 per cent of the fraction over 1.70, with 69.3 per cent of ash, the removal of which would give 90.6 per cent of float coal of only 4.1 per cent of ash.

Reduction of sulphur depends upon both the chemical and physical forms of the sulphur-containing components of coal. Some coals have an organic sulphur content so high as to preclude all possibility of reducing the total sulphur content to limits required for certain uses. Others may contain sulphur as pyrite particles so finely disseminated as to render its removal impracticable. Coals which contain the greater proportion of the sulphur in the form of coarse, free particles of pyrite are easily lowered in sulphur because of the high specific gravity of pyrite. (T. F. Yancey and Thos. Fraser in *Bureau of Mines Bulletin*, no. 300, 1929, 259 pp., 48 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING

The Statax Seven-Cylinder Rotary Engine

THE Statax engine, which was shown at the recent Aero-Exhibition, is a rotary, but unlike most rotaries the cylinders, of which there are seven, lie horizontally and parallel to what is, in effect, the crankshaft, the heads of the cylinders pointing to the front. By this arrangement the designer has been able materially to reduce the overall diameter of the engine. This is the obvious object of the design, since the more compact engine allows the airplane to which it is fitted to be better streamlined.

The difficulty has been to substitute for the crankshaft some other fixed point from which the engine will derive its rotation; the problem is solved in this case by means of a disk mounted on the central shaft and at an angle to that shaft, and attaching what amounts to the big end of the connecting rod of each cylinder to this disk. When the compressed mixture is fired the force developed, acting through the piston and connecting rod and the inclined plane formed by the disk on the central shaft, causes the cylinders and crankcase to rotate, the pistons traveling through a stroke corresponding to the degree that the disk is set at an angle to its shaft.

A further interesting point is that mixture is drawn in and exhaust gases expelled through ports covered and uncovered as required by a single sleeve valve between the piston and the cylinder proper, each valve deriving its movement from a cam plate as the cylinders revolve. For the purpose of cooling the exhaust port, air is drawn through the opening at certain points of the stroke.

The engine is a four-stroke and designed with the tractor-screw boss attached to and rotating with the cylinder head. (*The Autocar*, vol. 63, no. 1762, Aug. 9, 1929, p. 277, 1 fig., *d*)

A Carburetor for Heavy Fuel Oil on Locomotives

A DEVICE has been brought out which takes the place of an ordinary carburetor and actually gasifies low-grade fuel oils. This now makes it possible to operate standard internal-combustion engines on locomotives with fuel oils which can be purchased for approximately one-third of the price of gasoline.

This new device cracks the oil by the vapor-phase system. About one-fourth of the gases so formed are non-condensing. The device does not vaporize or spray the oil in the engine.

Referring to Fig. 1, in the combustion chamber *A* about 5 per cent of the fuel oil is burned with the aid of an air blast produced by the intake suction of the engine. Fuel for this fire is maintained at a constant level and is initially ignited by the spark plug as shown.

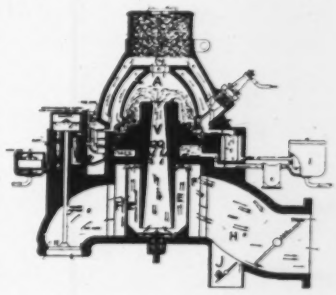


FIG. 1 GASIFIER FOR LOW-GRADE FUEL OIL

The hot gases of this fire are drawn downward through a venturi tube *V* into the cracking chamber *E*, which properly gasifies the main body of fuel which is sprayed directly into the hot gas column by venturi suction at venturi openings *QQ*.

Lack of air at this point prevents complete combustion of the new fuel, but its contact with the intense heat of the inert gases from the fire results in the oil's being instantaneously cracked into various gases of hydrocarbon combinations.

At the point where the oil is sprayed into the flame the temperature is as high as 2500 deg. fahr., which insures immediate and complete reduction of the oil introduced.

Water from the float chamber 15 is fed in with the raw fuel through the same venturi openings and assists in keeping the gasifier and the engine clear of carbon. Cooling is accomplished from contact of gases with the cool walls of the mixing chambers *F* so that when the gases mix with the air from air valve 11 to form the engine mixture, they will not ignite. The automatic action of air valve 11 automatically meters fuel and water by the action of metering pins 7 and 8 actuated by piston 12.

Engine intake connection *H* while drawing through the hot gases as described, also draws in air controlled by choke valve 18 through opening *J*, forming a properly proportioned and cooled mixture of gas and air for firing the engine cylinders. The temperatures of this mixture upon entering the cylinders vary from 200 deg. fahr. to 250 deg. fahr. (*Industrial Power*, vol. 17, no. 4, Oct., 1929, p. 42, 1 fig., *d*)

Why There Are No High-Pressure Diesel Engines

THE author attempts to determine to what extent an improvement in efficiency can be obtained by the use of higher working pressures. The thermal efficiency of a Diesel engine is

$$\eta_{th} = 1 - \frac{1}{\epsilon^{k-1}} \times \frac{\varphi^k - 1}{k \times (\varphi - 1)}$$

As the exponent k may be considered constant for the working cycle of a Diesel engine, an improvement in efficiency can be produced only by increasing the compression ratio ϵ or by decreasing the ratio of the maximum to the minimum combustion space φ. From the following it would appear that as the compression ratio ϵ increases, φ simultaneously decreases. For the sake of simplicity the author considers here merely a case where ϵ varies between 11.3 and 26, corresponding to compres-

sion pressures of 30 atmos. and 100 atmos. under the assumption that the consumption of fuel remains constant. For various changes of state under constant pressure the amount of heat supplied is

$$Q = G \times c_p\,(t_2 - t_1)$$

and hence

$$t_2 - t_1 = \frac{Q}{G \times c_p}$$

Let it be assumed that the heat content used in a cycle of combustion is $Q = 10$ cal., corresponding to 1 gram of fuel per stroke (assuming a heat content of fuel of 10,000 cal.), then the corresponding weight of air G, assuming an air consumption of 20 m. per kg. of fuel is $G = 0.024$ kg. Let it be assumed further that $c_p = 0.23$ is constant. With the magnitudes given above the equation becomes

$$t_2 - t_1 = \frac{10}{0.024 \times 0.23} = 1667 \text{ deg. cent.}$$

The final temperature of the air for adiabatic compression is found to be 827 deg. cent., hence

$$t_2 = 1667 + 827 = \sim 2500 \text{ deg.}$$

and

$$\varphi = \frac{V_2}{V_1} = \frac{T_2}{T_1} = \frac{2773}{1100} = 2.52$$

for a compression end pressure of 100 atmos. From this with $k = 1.4$ the thermal efficiency is found to be

$$\eta_{th} = 1 - \frac{1}{26^{0.4}} \times \frac{2.52^{1.4} - 1}{1.4 \times (2.52 - 1)} = 0.66$$

This may be compared with the thermal efficiency at 30 atmos. final compression pressure, which is

$$\eta_{th} = 1\,\frac{1}{11.3^{0.4}} \times \frac{3.23^{1.4} - 1}{1.4 \times (3.23 - 1)} = 0.49$$

From this it would appear that the thermal efficiency increases quite materially with increase in end compression pressure. From this the author proceeds to an investigation of the extent to which combustion, loss of heat through cooling and radiation, and mechanical losses affect the total efficiency.

In the case of a combustion process, losses occur through incomplete combustion. With the same excess of air as in a low-compression Diesel engine the combustion at high compression will be better because of the higher temperatures. Under these conditions even extremely viscous tar oils can be quickly vaporized and brought into mixture with the available air as a result of partial explosion. The more rapid combustion will also permit running the machine at a higher number of revolutions without materially increasing thereby the weight of fuel burned. From this point of view high compression appears to be particularly suitable for motor-car-type Diesel engines, which will have to operate at 1000 r.p.m. at least.

As regards the heat losses through cooling and radiation, these depend primarily on the temperature and surface area of the combustion space. From the *pv*-diagram it appears at once that at the end of the combustion stroke the surface of the combustion space in a 100-atmos. engine is considerably smaller than in a 30-atmos. one, which should equalize the higher temperature. Likewise at the end of the injection period the heat-transmitting surface is correspondingly smaller in the high-compression engine. From the diagram given in the original article, Fig. 2, it appears further that from a certain definite point on, a temperature in the high-compression engine is always lower than in the low-compression engine. This circumstance is of no inconsiderable benefit as the high temperatures occur during approximately one-fifth of the stroke, while during four-fifths of the stroke they are considerably lower than in the low-compression machines, and at the end of the stroke are as much as 450 deg. lower.

The mechanical losses are not expected to be greater in the high-compression than in the conventional-type Diesel engine.

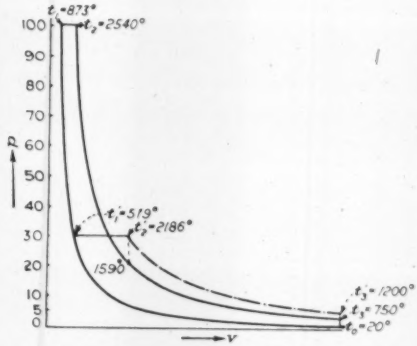


FIG. 2 *pv*-DIAGRAM FOR HIGH-PRESSURE DIESEL ENGINE

The higher friction due to the greater initial pressure is compensated for by the lower end pressure, so that the only factors that have to be taken into consideration are the greater weight of the moving parts and their possible unfavorable influence on the efficiency. This is considered in more detail in the original article. (*Maschinen Konstrukteur*, vol. 62, no. 15, Aug. 1, 1929, pp. 344–345, 1 fig., *ct*)

MACHINE PARTS (See also Standardization: Standardization of Keys and Keyways in Great Britain)

A Ball Bearing Without a Cage

AN INTERESTING innovation in ball-bearing design is reported from Berlin. The outstanding feature of the invention is that the usual cage is replaced by a third row of

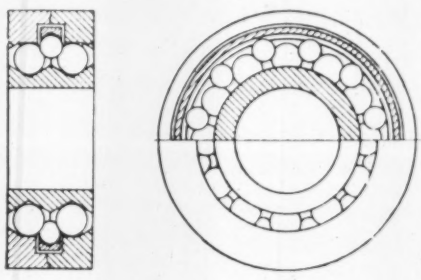


FIG. 3 A CAGELESS BALL BEARING

small balls located above and between the two rows of bearing balls. These serve solely to keep the main bearing balls from touching one another. The small distancing balls are held by a grooved ring which floats inside the body of the bearing.

Fig. 3 shows the general arrangement of the bearing. It will be noted that the inner ball race has two grooves, one for each row of bearing balls. The outer ball race is necessarily split to permit assembling the bearing balls, distancing balls, and floating ring.

It is claimed that with this type of bearing, sliding friction is entirely eliminated, rolling friction only occurring. Smooth running is improved, as demonstrated by the inventor in a rough experiment carried out to compare the efficiency of the new bearing with one of the standard makes and of exactly similar dimensions. It is stated that the new bearing (which is equipped with an exactly similar flywheel and given the same impulse as the standard bearing) ran three times as long as the normal one before coming to a standstill. Both bearings run perfectly dry, and the new bearing, it is claimed, is noiseless when running. The bearing of standard design gave out definite and distinct sounds. (*The Automobile Engineer*, vol. 19, no. 258, Sept., 1929, p. 316, 5 figs., *d*)

MEASURING INSTRUMENTS

Apparatus for Measuring the Cutting Pressure Exerted on Tool Edges

THE cutting pressure can be resolved into components acting in three different directions, namely, vertically downward, axially opposite to the direction of longitudinal feed, and radially opposite to the cross-feed. By employing a special measuring instrument made by the Losenhausenwerk, Düsseldorf-Grafenberg, the three components may be accurately measured and recorded on a chart.

In this device the turning tool rests on a block connected to dial gages which are employed to record vertical and radial forces and horizontal forces in either direction. The details of the instrument are described in the original article.

A variety of tests can be carried out with the measuring instrument. Thus the most favorable cutting speed and feed for a given material can be obtained, and, with the speed and feed rates and the cutting being kept constant, the most favorable cutting angle may be determined to secure the best possible life and the lowest possible power consumption.

For testing the machinability of the materials by drilling, a special drilling-machine testing table has been designed and is shown in the original article. This makes it possible to record the vertical drill pressure and torque. (*Machinery* (London), vol. 34, no. 884, Sept. 19, 1929, pp. 799, 3 figs., *d*)

METALLURGY

Hardening of Superhardened Steel by Magnetism—Lattice Resonance Hypothesis

THE author produced hardening of steel by a cloudburst process and followed this by low-temperature annealing. He found that there was an increase over the original hardness throughout the range of temperature from cold up to nearly 600 deg. cent (1112 deg. fahr.). It is believed that this process may be turned to advantage in increasing the cutting capacity of tools of high-speed steel. The tool having been heat treated in the ordinary way and superhardened by the cloudburst, could have its hardness further increased by annealing at 120 deg. cent. (248 deg. fahr.); or it could be put to work in its superhardened state and annealed by the heat generated in cutting.

The fact that annealing at such a low temperature produced such results would indicate that we are dealing here not with recrystallization or change of chemical constitution, but rather with some atomic rearrangement in the crystal structure. If so, some other stimulus could be applied to produce the same result.

The most likely stimulus in the case of a magnetic material appeared to be a repeated change of magnetic polarity, which might be expected to disturb or distort the lattice and thus assist it to fulfil the existing propensity toward a less unstable arrangement. With this end in view the following procedure was adopted.

A specimen of steel which had been work hardened by the cloudburst process was placed with the treated face downward across the poles of a powerful electromagnet and several taps were administered to the back of the specimen with a light hammer. The specimen was then turned through 90 deg. in relation to the magnet, and the light taps were repeated. This process was repeated until the specimen had been revolved 50 times in a clockwise direction by stages of 90 deg. with light hammering at each change of position. The direction of rotation was then reversed and 50 more revolutions were given—that is, 400 changes of position, with consequent changes in the direction of polarity.

The specimen was then tested for hardness with the pendulum. Its hardness was found to have been increased by the magnetic treatment to almost exactly the degree of hardness which it had been found possible to induce by the P_3 anneal in another portion of the same specimen.

The P_3 anneal and magnetic treatment appear to be strictly alternative processes producing the same atomic rearrangement. Thus, it was found that when the specimen which had been magnetically hardened was afterward subjected to the P_3 anneal, no further increase of hardness resulted. Likewise, the specimen annealed at P_3 showed no further increase of hardness when subsequently subjected to magnetic treatment.

The magnetic treatment has been applied to a diversity of steels work hardened or superhardened by cloudburst, and in every case the increase of hardness has resulted as anticipated. From a table in the original article it appears that the P_3 anneal and the magnetic treatment are equally effective, whether applied to soft steels work hardened or to hard steels superhardened, but in the latter cases the temperature anneal was carried out at 120 deg. cent. (248 deg. fahr.).

This is explained by resorting to a lattice resonance hypothesis, to which reference is made in the original article. (Edward G. Herbert in a paper before The Iron and Steel Institute; abstracted through *The Iron and Coal Trades Review*, vol. 119, no. 3212, Sept. 20, 1929, pp. 416–417, 2 figs., *et.A*)

MOTOR-CAR ENGINEERING

Steam-Vehicle Defects

THE author claims that it is doubtful whether any steam plant could be made having a thermal efficiency approaching that of an internal-combustion plant, especially of the Diesel type. But it is possible for a well-designed steam-propelled vehicle to be built having a much greater overall efficiency and be far more versatile than any other vehicle extant. When, therefore, the author entitles his article, "Steam-Vehicle Defects," he has in mind to call attention to points of design where improvements may be effected.

In reference to the type of boiler, he says that existing commercial steam vehicles are almost exclusively fired by coal or coke in a solid state, their generators being either of the vertical water-tube or locomotive fire-tube types. Both of these are slow in steaming from cold. The flash generator would appear to have material advantages, but is not being used today. Burning coal in its solid state is a very clumsy way of using the fuel, and the author calls attention to the possibilities of pulverized coal.

On short journeys, such as from docks to local warehouses, entailing much standing time the superheater of a solid-coal-fired lorry becomes a condenser, because the fire, after having been dampered down, is not in good condition until the vehicle has traveled a mile or two. An oil or pulverized-coal burner, on

the other hand, is working at its best almost immediately, irrespective of the time the vehicle has stood. The fuel and air can be varied to give almost perfect combustion under all conditions when using pulverized coal, so that smoke is eliminated and the maximum heat is obtained from the fuel used; discharge of unburnt fuel is greatly reduced and only fine particles of light ash are discharged, which would not be so annoying to other road users as the discharge from the funnel of existing steam lorries.

Oil firing, the author finds from personal experience, is both noisy and much more expensive than coal, though it is much more desirable from the driver's point of view. Possibly the high speeds of modern lorries may help the combustion of the fuel by arranging a boiler to travel firebox first, with the funnel at the back of the cab; then there would not be the necessity for such a high smokebox vacuum in order to burn solid fuel. However, solid-fuel-burning boilers are not ideal for real modern high-class steam vehicles; they are too heavy, too large, and too erratic in action.

The author discusses the cause of low thermal efficiency of steam engines and suggests a design of a small, high-efficiency engine with three cylinders with cranks set at 120 deg., working on the single-expansion, single-action principle, and having cam-operated poppet inlet valves and uniflow exhaust ports. The crankcase would be of accepted motor-car design, and pressure-fed lubrication would be used with the sump below the oil-pump suction, into which water of condensation would collect. Moving parts would be light and steam passages well designed, giving a real clear flow for the steam so that a very high speed could be attained. Possibly with present-day metals, oils, and fine limits of accuracy in manufacture, the crosshead in a single-acting engine could be eliminated with marked advantage.

A sketch in the original article shows a piston and cylinder, the design of which could be such that the compression at high speed would be great enough (or nearly so) to balance the poppet inlet valve; but at low speeds, especially if the condenser were pulling at the exhaust, the steam, having more time to escape, would be practically all out of the cylinder before the ports were covered, in which case the inlet valve would not be balanced.

Such a condition of things would not be at all detrimental to the running of the engine, but rather the reverse, for it is at high speeds that the easy opening of the valve is of such paramount importance. An engine is only used in reverse occasionally, and it might be advantageous to offset the cylinders a few degrees in such an engine, as is sometimes done in high-class gasoline-engine practice.

The author discusses next the matter of valves and finds that piston valves are mechanically preferably to D-slide valves, though they are more expensive and have the further disadvantage of being unable to release water trapped in a cylinder as easily as does the D-valve by lifting off its seat.

Among further disadvantages of the over-type engine is the crude character of its lubrication, bearing troubles, unsuitability to mass production, and lack of comfort to the driver. The author mentions, however, a design which he has seen containing some novel features. The boiler is a modified locomotive type having water tubes instead of fire tubes, while the engine calls for special comment. It is of the double enclosed high-speed type with pressure-feed lubrication and Cop valve gear, and though only half the weight of the engine it is intended to replace, it has much more power. Furthermore, it is easily and quickly detached from the boiler and is designed for mass production.

The author discusses next the under-type engines and considers their advantages. The article is to be concluded in a later issue. ("A Contributor" in *Motor Transport*, vol. 49, nos. 1278 and 1279, Sept. 9 and 16, 1929, pp. 323–325 and 347–349, illustr., *dc*)

NATIONAL DEFENSE

Mechanization and Realization

THE author is a brigadier of the British Army in command of a brigade formerly at Wiesbaden, Germany, and in his article emphasizes the fact that at least in the British Army it is not so much the actual progress of mechanization as the change of spirit with respect to the new methods of warfare that deserves particular attention. Some quotations from the original article follow.

"In 1918 the World War was won by motorized weapons and vehicles: by warships, by airplanes, by tanks, locomotives, and lorries. It was won by militarized science and industry, and it was not won by fighting man power, which dismally failed to accomplish its end in the earliest stages of the war. Immediately peace was concluded, like a scattered mosaic the picture of the winning of the war was lost; few parts of the general panorama actually disappeared, but each part became separated from the rest, and so completely separated that, were it possible for another great war to be declared today, every country except England would enter that war as blind to its reality as they were blind to the reality of 1914.

"That I have excepted my own country may seem presumptuous, but I am sufficiently well acquainted with the progress of military organization on both sides of the Atlantic to know that this presumption is a fact which, though it may be quibbled at and criticized, cannot logically be refuted. In 1919 there were not a dozen soldiers of any note in the British Army who supported mechanization, and as late as the autumn of 1927—that is, less than two years ago—an English general officer commanding-in-chief, and therefore an exalted personage, could still say: 'Now, we have heard a great deal about the infantry being helpless in face of these tank attacks. My personal opinion from what I have seen is that it is not so at all, and I think that with the improvement of anti-tank weapons and practice in quick dispersion, it is still less likely to be true. I hope no infantry officer thinks it. I have no doubt that infantry will learn to meet an attack by tanks with the same confidence that they learned to meet an attack by cavalry and the *arme blanche*.' Today, no subaltern officer in England, I will not yet say in the British Empire, could deliver himself of such claptrap.

"As late as February, 1921, a cavalry officer claimed that the cavalry will never be scrapped to make room for the tank. Eight years later the Army Council, the brain of the British Army, issued the first manual published in any army on the new tactics, under the title of 'Mechanized and Armored Formations,' and in it, among other things, may be found the following:

"'At the present time an open and flexible mind is, therefore, one of the first qualifications of an officer.

"'By increased mobility the art of generalship is enhanced.

"'In favorable country the mobility conferred by mechanization is greater than has ever been attained by mounted troops.

"'Some cavalry will be required for close reconnaissance in front of the infantry, unless the latter are carried in mechanical transport and equipped with mechanical first-line transport, in which case light tanks will take the place of divisional cavalry regiments.'

"Such a manual, had it been published ten years ago, would have been of little value because it would have met with a hostile reception. Today it is welcomed, for the mental outlook of the officer and the soldier has changed, a change due to propaganda and force of circumstances—the general introduction of the motor car."

The author then considers the history of war as affected by such primary inventions as powder, bayonet, rifle, and gun.

"The whole of this period, that is, from 1861 to 1914," he

says, "is one of the most interesting in the whole history of war, because the tactical idea which controlled it was one which assumed that soldiers themselves could be mechanized, that is, that men could be turned into machines. The soldier was looked upon by the military designers as a self-propelled gun mounting, or mobile biped, upon which was to be fixed a rifle. Steam power had produced a rifle, it had also produced the locomotive which enabled masses of men to be moved and assembled, but it had not produced the man himself. This was the one point the strategists and tacticians have overlooked, when in the quietude of their studies and lecture rooms they had moved imaginary masses over their maps, forgetting that their flagged pins and little blocks of colored lead were soulless things, and that in order to perfect, and even render possible, their destructive machines—their armies—it was imperative that they should protect the man, who as a soldier on the battlefield always prefers to live than to die."

In this connection he points out that as early as 1870 no single frontal attack made by the French or Prussians succeeded in its object. Mechanical genius had so enhanced bullet power that the rifle on the defensive was always superior to the rifle on the attack. The trench helped still more the position on the defense side, but was useless for the attacking part because it was not mobile. The tank gave this mobility together with protection. Moved by the machine and being to all intents and purposes invulnerable to bullets, the soldier could devote the whole of his thoughts and energy to the manipulation of offensive weapons.

As regards the future, the author believes that the infantry portion of the army is obviously that part which should establish the base of tank operations. For although it is unable to meet the tank in the field, it can improve and construct anti-tank obstacles and defenses. This means that motorized infantry must become anti-tank engineers, that they will discard their rifles, bayonets, and entrenching tools, and will instead be equipped with guns, land mines, and mechanical diggers.

"From the protected base, air and armored forces will operate—and what types of machine will armored fighting demand? We start with the two essential types—the tank and the anti-tank (or better named, the tank destroyer). The tank is the out-fighting arm and the destroyer the in-fighting, and both must seek protection not by constructing obstacles but by gaining information; thus we require a third type of machine.

"In tank specifications in England we have, since the close of the war, consistently, followed a costly and erroneous path. We have been hallucinated by cost and size, and have hoodwinked ourselves by inventing a misleading nomenclature—we talk of light, medium, and heavy tanks, in place of laying down the functions of the machines we require and then building machines which express these functions. If in place we thought in terms of battle tanks, destroyer tanks, and reconnaissance, or scout, tanks, our designing and building programs would be comparatively easy ones, because these names would suggest to us what we want." (J. F. C. Fuller in *Army Ordnance*, vol. 10, no. 56, Sept.-Oct., 1929, pp. 90–94, 3 figs., *g*.1)

POWER-PLANT ENGINEERING

Power From Wood Refuse

AT THE Mengel Co., Louisville, Ky., a large amount of wood refuse is accumulated in the manufacture of automobile-body woodwork. A new boiler house was recently installed and has been particularly adapted to burn this refuse. Two boilers have been installed so far, each having a heating surface of 8600 sq. ft., and the addition of a third one is contemplated. As the supply of wood fuel was not expected at all times to equal the demand, a large storage bin was provided for firing pulverized fuel. The wood fuel is prepared for burning by passing it through a hogging machine, a device which reduces the wood to chips or shreds. The hogged fuel is delivered by a cyclone collector to the top of the fuel-storage bin which has a capacity of 320 tons, and from there by a conveyor and bucket elevator to the storage hoppers located in front and above the boilers. The fuel is conveyed from the storage hoppers through three separate stokers to each boiler. The stokers act not only as conveyors but likewise as a proportioning device, regulating the rate of fuel in proportion to the steam demand. The amount of wood conveyed to the boilers is controlled by steam-pressure regulators, automatically adjusting the paddle rotary feeder wheels that finally dump the fuel into the furnace.

The large furnace volume permits a heat release of approximately 12,000 B.t.u. per cu. ft. per hr. at 200 per cent of rating, and about 18,000 B.t.u. per cu. ft. per hr. at 300 per cent of rating. When operating at 300 per cent of rating with 15 per cent CO_2 in the furnace gases, the average furnace temperature is approximately 2400 deg. fahr., and approximately 2200 deg. fahr. at 200 per cent of rating. When operating at 200 per cent of boiler rating an overall efficiency of 76 per cent to 78 per cent is obtained. Flow meters, CO_2 equipment, and other regulatory devices were installed. It was anticipated that such an installation would function properly, and the efficiencies secured have demonstrated this. (H. R. Lambright, Power Engr. of Mengel Co., in *Industrial Power*, vol. 17, no. 4, Oct., 1929, pp. 39–41, 3 figs., *d*)

Lignite Power Stations in Germany

THE author states that the utilization of lignites for steam-electric power generation is much further advanced in Germany than in any other part of Europe, 160,000,000 tons of lignite being annually burned there.

Of this amount about 67 to 70 per cent is used for making briquets, 18 to 22 per cent for combustion in the raw state, 9 to 10 per cent for total gasification, and a small amount for low-temperature carbonization, etc.

The average figures of moisture in German lignites vary from 42 to 60 per cent. Nevertheless a number of the largest power stations are being operated with raw lignite alone, both in lump condition on mechanical stokers and in the pulverized state after drying down to a limit of 15 to 18 per cent moisture.

As usual with these German lignite stations, the raw fuel is mined alongside by open-cut or strip working, first removing the overburden and then the lignite. The exact methods vary according to the conditions, but essentially the most modern German practice, with a gigantic output of anything from 10,000 to 25,000 tons of lignite per day from a single mine, consists in the use of special multiple-bucket, endless-chain, "dredger" excavators, which can be electric, steam, Diesel-engine, or gasoline-engine driven, and run either on rails or caterpillar-tractor wheels. The very latest method, however, can be regarded as electric-driven, multiple-bucket "dredger" excavators with caterpillar-tractor wheels, both for the overburden and the lignite, and in a large number of cases the overburden dredger excavators are operating in direct conjunction with an overhead traveling-belt conveyor or bridge (*Abraumförderbrücken*) which continuously deposits the overburden in another part of the mine as fast as it is excavated. The lignite is loaded continuously into very large steel cars hauled by electric locomotives, traveling along at a greater speed underneath the discharge of the multiple-bucket dredger excavator, which is also moving.

At the Golpa Lignite Mine the seams vary from 2.75 to 21.50 m. (9.0 to 70.5 ft.) in thickness, but average about 11.90 m. (39.0 ft.). The moisture content, as mined, is 53 to 55 per cent.

with a heating value in the dry state of 8300 to 9500 B.t.u. (4610 to 5294 kg.-cal. per kg.). The average depth of the overburden is 18.0 m. or 57.25 ft.

During the past few years the methods of mining at Golpa have been revolutionized on the lines indicated, and it may be stated that today about 10,000 tons of lignite, in addition to all the overburden, is excavated per 24 hr. with about 1190 men, divided into two shifts, whereas not so long ago over 4000 men had to be employed for this work. The huge boiler plant at Golpa-Zschornewitz is divided into six separate boiler houses, of which five each have 16 water-tube boilers of 500 to 575 sq. m. (5382 to 6190 sq. ft.) heating surface, while the remaining boiler house—just recently completed—has 12 boilers of larger size, 1000 sq. m. (10,764 sq. ft.). That is, the complete installation comprises 92 boilers with a total heating surface of 52,000 to 58,000 sq. m. (559,728 to 624,312 sq. ft.).

In general, the method of firing adopted for the raw lignite is to use mechanical stokers of the deep-trough or step-grate type, and it has been proved conclusively, as the results of the most extensive experience, that this design of stoker is much superior for raw lignite than any traveling-grate type, confirmed also after disastrous experiences at the working of the Yallourn Power Station on Morwell lignite in Australia. At the same time, however, many of the boilers at Golpa-Zschornewitz are now fitted with auxiliary pulverized-fuel firing using predried lignite, and the results obtained are excellent, each boiler being equipped with a complete battery of control instruments on the latest scientific lines.

One of the most formidable problems at Golpa-Zschornewitz has been the handling of the ash and the prevention of dust with such a friable raw material as lignite, and it may be stated that the ash turned out amounts to about 350 metric tons per day, this being handled largely by means of powerful water-jet conveyors.

Finally, it may be stated that at Trattendorf and Lauta the operation of the boiler plants is on the same general lines as at at Golpa-Zschornewitz, that is, using deep step grates, with mechanical operation of the conveyors and also auxiliary pulverized-fuel firing. (David Brownlie, London, in *Combustion*, vol. 1, no. 3, Sept., 1929, pp. 25–28, illus., *g*)

Is the Boiler With Welded Seams Safe?

THE technical report for 1928 by Harry M. Longridge, Managing Engineer of the British Engine Boiler and Electric Insurance Co., would seem to raise considerable doubts about this. This report is not limited to electric welding but covers also the oxyacetylene method. It states that during recent years there has been an increasing tendency to employ fusion welding in the production of pressure vessels. There are no official rules or regulations in England which would guide the design of such welded vessels. From the point of view of the insurance company, the report states, the riveted joint is preferably to the welded joint. At the same time, in view of the fact that welding is very often the most economic method of making a joint and that it is a convenient method of obtaining tightness, a welded joint is entitled to consideration as an approved form of construction for an unfired pressure vessel, provided that it is properly designed and constructed. The disfavor with which welding is sometimes regarded is in a large measure due to lack of control in matters of design and manufacture, whereas with vessels made to rigid regulations the undesirable elements would, to a large extent, disappear. The main bulk of the accidents that have occurred have been due to welding having been carried out in a manner that no supervising authority could tolerate.

As to welded boilers, the inquiry was for the most part limited to the construction of non-fired pressure vessels.

Longridge himself seems strongly opposed to welding for boilers under steam, even if welding be suitable for vessels subject to cold-water pressure. In the numerous examinations the company has made of faulty joints, it is said faults have never been found of the same magnitude in a riveted as in a welded seam. Though welded boilers are in service on the continent, says the report, evidence is still lacking that this class of construction, even when of the highest order, will reduce the troubles so common at seams. If welded seams in a boiler are to have the same margin of safety as riveted seams, a radical departure from present design and practice will be necessary and thus make the welded construction much less attractive to the manufacturer. The Board of Trade rule in England lays down that no joint in tension shall be welded.

The efficiencies of some of the principal joints are given by the author in tabular form in Fig. 4. The values given have been found readily obtainable with reasonably well-made welds. The following explanatory notes are given.

1 The efficiencies compare the strength of joints in plates of thickness t with the strength of a plate of the same thickness when butt welded, but without reinforcement.

2 The efficiencies refer to joints of the same width as the plate.

3 With fillet welds the efficiencies apply when the fillets have an approximately straight contour, lying at 45 deg. with the surface of the plate. The efficiencies also apply to other contours as long as the throat thickness is not less than 0.69 t.

4 A joint may be readily made stronger than the body of the plate away from the joint. As the efficiency refers to the joint itself and not to the plate, it follows that a higher efficiency than 100 per cent can readily be obtained. It has been possible to record efficiencies where they exceed 100 per cent by the adoption of specially designed test pieces.

5 It must not be inferred that all the joints shown are permissible for pressure vessels; the figures given apply to a static tensile test, and it does not follow that the behavior of joints subjected to the stresses of service will be in proportion to the efficiencies given.

6 The strengths quoted apply only when the load is applied in the manner shown in the sketches. The efficiency is therefore in some instances superior with the joint applied to the circumferential seam of a pressure vessel, and sometimes inferior when it is applied to a longitudinal seam.

Mr. Longridge does not propose, he remarks, to enter into a dissertation on the relative qualities of various electrodes. This forms too large a subject and would be out of place. Likewise a summary of all the qualities essential for satisfactory operation would form too long a list. He therefore limits himself to stating only what are considered to be the most necessary properties for metallic electrodes used for welding pressure vessels. These are:

1 The electrodes should contain not more than 0.03 per cent of phosphorus, not more than 0.05 of sulphur, and not less than 0.50 per cent of manganese. A higher percentage of manganese is strongly recommended.

2 The rod should have a covering which has strong deoxidizing properties, and which will react chemically with the mill scale and any rust on the plate being welded, and cause a slag to be formed which will protect the surface of the weld from exposure to atmosphere.

3 The covering should have a melting temperature below that of the steel, preferably not more than 1000 deg. cent., in order that the operating current may be kept low, reducing the expansion of the welded part and the liability of the metal to be overheated and allowing the molten slag to separate readily from the weld metal.

4 The slag should have a coefficient of contraction greater than that of the metal, so that it may be removed easily.

5 The electrode should be protected against rusting in a damp atmosphere, either by covering or by some other suitable means.

6 The covering should be capable of withstanding temperature changes and the usual rigors of service that are to be expected during manipulation without cracking.

7 The electrodes should deposit weld metal free from porosity and high in ductility.

The following additional properties are deemed necessary to meet special conditions of service:

8 When an electrode is used in a position where it has to be bent, the covering should be sufficiently plastic for a portion of the electrode 9 in. long to be bent to a right angle without the coverings showing any signs of flaking off, the test being made after the electrode has been dipped in water and redried.

9 When the electrode is used for fireboxes of boilers, the quality of the deposited metal should be such that strips cut from the welded plates can, while at red heat, be bent and flattened without showing defect.

10 When welds are hammered hot while metal is being deposited, or when the welded article is subsequently forged or subjected to deformation when hot, the quality of the weld metal should be such that strips of welded plate can, when at red heat, be forged down to half their original area without showing defect.

It is not denied that many excellent welds are made, and indeed a number have been examined during the course of the inquiry; but the quality of the ordinary commercial weld falls far short of the ideal, while many welds are definitely bad. Regulations, Mr. Longridge feels, are required if the legitimate development of welding is not to be retarded, and until such regulations are framed and enforced it is inevitable that trouble and disappointment will be the lot of makers and purchasers alike. (*The Electrical Times*, vol. 76, no. 1977, Sept. 12, 1929, pp. 369-371, c.4)

FORM OF JOINT	η	REMARKS
NON-REINFORCED BUTT WELD.	100%	
LAP WELD WITH SINGLE FILLET (SUBJECTED TO BENDING).	50%	UP TO ½ PLATE FOR CIRCULAR SEAMS. QUITE UNSUITED FOR LONGITUDINAL SEAMS OF PRESSURE VESSELS.
SINGLE BUTT STRAP (OF THE SAME THICKNESS AS THE PLATE)	50%	ditto. FOR MODIFICATION OF STRENGTH WITH SHAPE OF FILLET SEE SECTION IV FIGS X TO XV
LAP WELD (NO BENDING).	60%	
LAP WELD WITH TWO FILLETS (SUBJECTED TO BENDING)	100%	l NOT LESS THAN 3t. ONLY SUITABLE FOR LONGITUDINAL SEAMS OF PRESSURE VESSELS WHEN t DOES NOT EXCEED ⅜".
HALF-LAP JOINT WITH TWO FILLETS (NO BENDING) (OF THE SAME THICKNESS AS THE PLATE)	120%	
DOUBLE BUTT STRAPS (OF THE SAME THICKNESS AS THE PLATE)	120%	
JOGGLED LAP JOINT	133⅓%	l NOT LESS THAN 2t. ONLY SUITABLE FOR LONGITUDINAL SEAMS OF PRESSURE VESSELS WHEN t DOES NOT EXCEED ⅜"
JOGGLED LAP JOINT.	133⅓%	ditto.
BUTT WELD WITH SINGLE STRAP OF HALF THE PLATE THICKNESS.	-	AN UNSATISFACTORY FORM OF JOINT. BENDING STRESSES ARE INTRODUCED & COMPLEX STRESSES SET UP AT THE FILLET WELDS, WITH THE RESULT THAT THE STRAP ONLY INCREASES THE STRENGTH OF THE JOINT INAPPRECIABLY ABOVE THAT OF A PLAIN BUTT WELD
BUTT WELD WITH SINGLE STRAP OF FULL PLATE THICKNESS. (OF THE SAME THICKNESS AS THE PLATE.)	SAY 120%	AN UNSATISFACTORY FORM OF JOINT NOT RECOMMENDED FOR PRESSURE VESSELS.
BUTT WELD WITH DOUBLE STRAPS OF HALF THE PLATE THICKNESS.	160%	
SPECIAL FORM OF LAP JOINT. WELD METAL IN SHEAR.	80%	η = STRENGTH IN SHEAR / do IN TENSION OWING TO THE DIFFICULTY IN MAKING A WELD OF THE FORM SHOWN, THE EFFICIENCY SHOULD BE TAKEN NOT HIGHER THAN 70%
TRANSVERSE COVER STRAPS, WELDED AT THE SIDES ONLY.		THE STRENGTH DEPENDS ON THE FORM OF FILLET & IN GENERAL FRACTURE TAKES PLACE AT THE PLACE INDICATED BELOW.
DOUBLE STRAPS OF HALF THE PLATE THICKNESS, OPPOSITE ONE ANOTHER.	90%	THE STRENGTH OF THE WELD PER UNIT LENGTH IS 75% THAT OF A LAP WELD AT THE END OF THE STRAP.
SINGLE STRAP OF FULL PLATE THICKNESS.	75%	
SINGLE STRAP OF HALF THE PLATE THICKNESS.	45%	THE RESULT IS RELATIVELY HIGHER THAN BEFORE, OWING TO THE STRAP RECEIVING GREATER SUPPORT AGAINST BENDING.
TRANSVERSE COVER STRAPS WELDED AT ALL SIDES.		
DOUBLE STRAPS OF HALF THE PLATE THICKNESS, OPPOSITE ONE ANOTHER.	150%	FOR INFORMATION ON BUTT JOINTS WITH COVER STRAPS SEE SECTION III, TABLE I & THE SUBSEQUENT LETTERPRESS.
SINGLE STRAP OF FULL PLATE THICKNESS.	125%	
WELDED FLANGES.	-	SEE SUBJECT MATTER RELATING TO FIGS XI TO XIV SECTION IV.
BRANCHES & OTHER FITTINGS AFFIXED BY A FILLET WELD.	-	SEE SUBJECT MATTER RELATING TO FIG XXVI, SECTION IV.

FIG. 4 TABLE OF EFFICIENCIES OF SOME OF THE PRINCIPAL WELDED JOINTS

REFRIGERATION

Rapid Freezing and Chilling of Fish and Meats in Atomized Brine

THIS method has been developed by M. T. Zarochenzeff, of Russia. The fundamental principle of the system is based on the great conductivity of atomized (finely pulverized) brine and great velocity of the refrigerating agent which permits very rapid extraction of heat. His method has two applications: direct contact, as in case of fish and larger cuts of meat, and indirect contact, whereby the product is placed in metal containers, thus preventing penetration of brine.

Fig. 5 illustrates a typical arrangement of the chambers for freezing. The product is suspended from overhead rails and subjected to atomized brine, which very much resembles mist or fog. In order to freeze small cuts of meat, fish, or other small products by means of indirect contact, an arrangement has been devised by which a mesh or net conveyor passes through a tunnel with atomized brine. The product, packed in a case, is then placed on a conveyor and it is frozen in a very short time.

The first installation of this system was made in Reval, Esthonia, and is said to be on a commercial scale. Data of the results obtained by this installation are shown in a table in the

original article. Other recent installations include one on the Italian fish vessel *Naiada* which was equipped with chambers for the rapid freezing of fish on board. The original article gives some data of the demonstrations made with this vessel.

Fish of various sorts and sizes weighing 0.66, 1.54, 2.2, 4.4, 18.8, and 0.088–0.11 lb. were frozen. On January 9 separate lots of small and large units were treated. The temperature of the brine was 3.2 deg. fahr. The first inspection—made at the end of 10 min.—found the small fish completely frozen, the large fish of 4-lb. odd were still soft. At the end of another quarter of an hour the larger pieces were hard at the surfaces

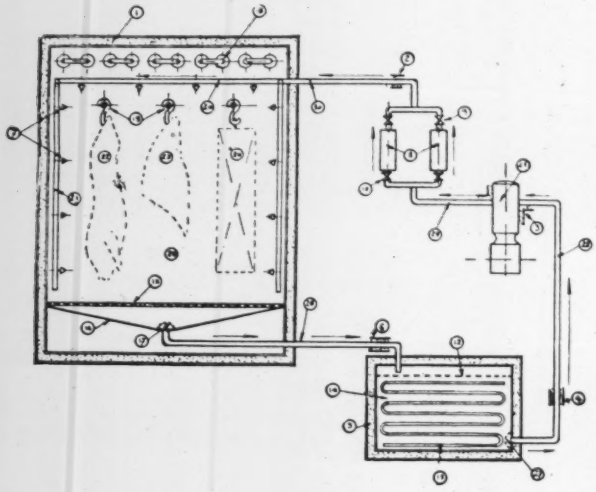


FIG. 5 TYPICAL ARRANGEMENT OF CHAMBERS FOR FREEZING BY ATOMIZED BRINE

of the containing baskets and soft at the center. Twenty minutes later (i.e., after 45 min. altogether) the big fish were hard. The working of the pump was resumed after a stoppage of 10 min., and 15 min. later all the large fish were perfectly frozen—separately and not in a mass.

Several other installations are mentioned, among others one in Paris at the Vaugirard Cold Stores. (*Ice and Refrigeration*, vol. 77, no. 3, Sept., 1929, pp. 155–156, 4 figs., *d*)

STANDARDIZATION

Standardization of Keys and Keyways in Great Britain

AN EXTENSIVE PAPER telling of the inner history of this particular standardization activity of the British Engineering Standards Association. The work started with the appointment of a committee and submission of a questionnaire to a large number of users and makers of keys. This was followed by experiments carried out to determine the depth of the key in relation to its width and the depth of immersion of the key in the shaft. These experiments resulted in the following decisions:

1 That the width of the key should be one-quarter of the diameter of the shaft.

2 That the depth of the key should be two-thirds of the width.

3 That the immersion of the key in the shaft should be half the depth of the key, measured on the center line.

This resulted in the First British Standardization Specification for Keys and Keyways, No. 46, Sept., 1909. After the publication of this specification it became clear that among well-known engineers there was still some doubt that the committee's standard key satisfied all conditions in practice, particularly in the case of reversing stresses thrown upon a key.

This led to the design of a pneumatic testing machine, which was eventually built by Reavell & Co. and installed at the National Physical Laboratory. It is illustrated and described in the original paper. Among other things, tests were made to determine the relative value of square keys and rectangular keys.

The results appeared to indicate that with mild steel the deep key was preferable, while with forged steel the results were reversed. There was, however, so little difference between the two that no definite conclusion as to relative merit could be drawn. It was apparent that the smaller of the two keys was amply strong with mild or forged steel when used on an overhung shaft.

Careful measurements of the keys and keyways before and after the test showed that practically all the deformation took place in the keyway in the shaft, and further, that, as would be expected, the greater part of this deformation took place near the fixed end of the shaft where the elastic displacement was necessarily least.

The work was held in abeyance from the outbreak of the war to November, 1922. At that time it was decided to carry out a further series of tests at the National Physical Laboratory with the same pneumatic testing machine but on steel shafts of higher tensile strength. The results of the tests generally show that up to a torque of 15,000 lb-in. the larger key is superior to the smaller one in that no movement could be detected, but at torques of 20,000 lb-in. the behavior of the two keys was very much the same. The results confirm the conclusions from the first series of tests, namely, that the $^{5}/_{8}$-in. $\times$ $^{7}/_{16}$-in. key is amply strong when using shaft material of an ultimate strength up to 44 tons per sq. in. Specification No. 46 was reviewed and tables were prepared for rectangular parallel keys, square parallel keys, rectangular taper keys, and square taper keys.

The tolerances for standard key bars for these were also determined, and the taper keys of each class were so proportioned that the same key bar would serve. Keys for shafts from $^{3}/_{16}$ in. to 12 in. in diameter were provided for. In every case the key can be cut off from the finished bar, and by a few strokes of the file can be fitted into the standard keyway.

The rectangular key has still a width nominally one-quarter of that of the shaft diameter, and a depth two-thirds of its width.

Regarding immersion of the key in the shaft, it has been found more convenient for shop practice to make the immersion of the key half its depth at the sides of the key instead of on the center line.

The work includes such special features as gib-headed keys, peg feather keys (keys of square section largely used in the construction of machine tools), coned and keyed shaft ends, tangential keys, Woodruff keys and keyways; splines, serrations, and taper pins.

The following standard nomenclature has been adopted:

Key. A key is a piece inserted between the joint of two parts to prevent relative movement. For the purpose of this specification a key is defined as a piece inserted in axial direction between a shaft and a hub to prevent relative rotation.

Keyway. A recess in a shaft or hub to accommodate a key.

Plain Parallel Key. A key of rectangular or square section; uniform in thickness and width and with squared ends.

Round-Ended Parallel Key. A plain parallel key with ends rounded as to width.

Plain Taper Key. A key of rectangular or square section uniform in width; tapered in thickness and with squared ends.

Round-Ended Taper Key. A plain taper key as defined above, but with ends rounded as to width.

Gib-Head Key. A key provided with a head to facilitate withdrawal.

Sunk Key. A key partly in the shaft and partly in the hub.

Hollow Saddle Key. A taper key fitting a keyway in the hub.

the bottom of the key being formed to fit the cylindrical surface of the shaft.

Flat Saddle Key. A taper key fitting a keyway in the hub and flat on the shaft.

Feather Key. A key attached to one member of a pair and permitting relative axial movement.

Single-Head Feather Key. A feather key with projection at the end to prevent its axial movement in the hub.

Peg Feather Key. A feather key with a peg to prevent its relative movement in the part to which it is attached.

Double-Head Feather Key. A feather key with a projection at each end to prevent its axial movement in the hub.

Dovetail Key. A key having one portion of its cross-section of dovetail form.

Round Key. A key of circular section fitted in a hole drilled partly in the shaft and partly in the hub.

Woodruff Key. A key being in form a segment of a parallel-sided circular disk.

Woodruff Keyway. A segmental recess in a shaft to accommodate a Woodruff key.

Tangential Keying. The use of keys acting tangentially in opposite directions.

Stake Keying. The use of taper keys for centralizing the hub on the shaft and for preventing relative movement. They may be hollow or flat saddle keys.

Spline. A key-like projection integral with a member of a pair.

Spline Shaft. A shaft having one or more splines. Spline shafts are designated by the number of splines, e.g., a six-spline shaft.

Spline Hub. A hub having one or more splines.

Serrations. A number of V-shaped splines cut in both members of a pair.

Fitting. Top and Bottom Fitting: When the key bears hard on top and bottom and lightly on sides. Side Fitting: When the key bears hard on sides and lightly or not at all on top and bottom.

In the discussion which followed, R. G. C. Batson referred to the statement that the old standard rectangular key was slightly deficient in the matter of immersion in the shaft when used with mild-steel shafts. He stated that this fact could be shown from a consideration of mechanical properties of the materials provided certain assumptions were made, and gave a mathematical calculation proving that failure occurs by distortion of the keyway due to insufficient immersion of the key.

Prof. G. F. Charnock wrote in reference to spline shafts that apart from the question of cost, the multiple spline was undoubtedly the ideal method of keying, especially for hollow shafts of rather large diameter. According to the standard referred to, in the case of a shaft 6 in. in diameter there were 48 splines, 0.194 in. broad and 0.074 in. deep, and with the shaft of steel and the boss of cast iron, some were afraid that the splines in the boss were not strong enough and might shear under shock. Following the ordinary method of calculation, in which the strength of one spline was multiplied by the total number of splines, it was of course easy to show that both shaft and boss were of ample strength, having such high factors of safety that abundant provision was made against shock.

But in the case of multiple splines it was extremely unlikely, with the most perfect workmanship imaginable, that all the splines would come into bearing uniformly, and it was almost certain that many of them would receive more than their fair share of the load. It was even possible that the greater part of the load might come upon a small number of splines, leaving the remainder comparatively free. An allowance should therefore be made on account of the difficulty of getting all the splines to fit simultaneously. This would, of course, vary with the nature and design of the work and the quality of the workmanship. He had been unable to find any records of actual tests having reference to this point, in the absence of which any value which might be assigned as the strength of the splines was largely a matter of assumption. With the limits of tolerance usually adopted in machine-tool work, it would appear that a reduction of from 25 to 40 per cent on the results of the ordinary calculation should be ample to cover all imperfections of spacing, and even taking the latter extreme figure, the factor of safety still remained ample. (Wm. Reavell, Past-President, I.M.E., in the Proceedings of the Institution of Mechanical Engineers, No. 2, 1929, original paper pp. 277–301, illus., and discussion, pp. 303–315, illus., *p.A*)

TESTING AND MEASUREMENTS

A Method of Measuring the Periodic Error of a Mechanism

A SIMPLE apparatus has been devised in the Metrology Department of the National Physical Laboratory for determining the periodic error in the motion transmitted by a kinematic pair. Various cases arise in practice, such as the relative motion of the toolholder and the spindle of a screw-cutting lathe, where a periodic error is one of the defects most frequently found reproduced in the pitch of a screw. Another example of considerable practical importance is that of the work-table motion of a gear-hobbing machine. Here a master wormwheel under the table is revolved by a worm, and the combined tooth action is liable to induce a periodic angular motion superposed on the continuous rotation of the table. This has undesirable results on the gears cut on such a machine, and is probably one of the principal causes of noisy running. Some simple method of testing the magnitude of such an error should help to eliminate at the source one of the possible defects of large reduction gears.

The apparatus consists of two similar electromagnetic markers which are connected in series so as to produce a series of simultaneous "kicks" on smoked-plate records attached to the two components of the kinematic pair. The mechanism is allowed to move at a very slow rate, and a tapping key in the circuit is continuously closed and opened. The record may be in the form of a circle or a straight line, according to the kind of mechanism. It is important to obtain a deadbeat movement.

The markers give a series of simultaneous displacements of the two components from which a periodic-error measurement can be derived. An example in the original article shows an actual record of test of the periodic motion of a hobbing-machine table during one revolution of the driving worm. The curve gives an indication of the order of accuracy the method is capable of giving which is well within 0.002 in. A feature of the method of real value is that it can be applied very readily to test any mechanism in place under exact working conditions. (G. A. Tomlinson in *Journal of Scientific Instruments*, vol. 6, no. 5, May, 1929, pp. 152–153, 3 figs., *d*)

Salary Curves for Engineers and Their Interpretation

THE author considers how curves or charts showing compensation received by engineers should be drawn. He claims that average salary curves should not be used as they are apt to mispresent facts, because many engineers have incomes outside of the straight salary. From his charts it would appear that an engineer forty years of age receives a mean average salary of about $3500 per year, while when sixty years old he receives about $2300. He emphasizes, however, that average salary curves in themselves mean nothing. (Arthur Richards, Second Vice-President, American Association of Engineers, in the *Professional Engineer*, vol. 14, no. 8, August, 1929, pp. 14–15, 2 figs., *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Standardization of Milling Cutters and Cut and Ground Thread Taps

THE Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements has completed its third and fourth proposed American Standards for (*a*) Milling Cutters, and (*b*) Cut and Ground Thread Taps. These proposals are now passing through the final stages necessary for their approval as "American Standards." The Sectional Committee, it will be recalled, was organized in September, 1922, under the procedure of the American Standards Association, with the National Machine Tool Builders Association, the Society of Automotive Engineers, and The American Society of Mechanical Engineers as joint sponsors.

Small Tools and Machine Tool Elements

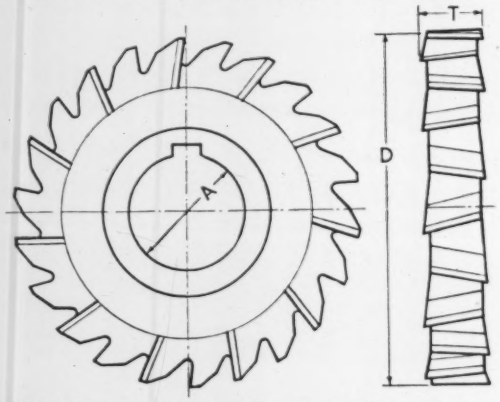


Table No. 5. Stagger Tooth Milling Cutters

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 1/2	2.515	2.485	1/4	.2500	.2495	7/8	.876	.875
2 1/2	2.515	2.485	5/16	.3125	.3120	7/8	.876	.875
2 1/2	2.515	2.485	3/8	.3750	.3745	7/8	.876	.875
2 1/2	2.515	2.485	1/2	.5000	.4995	7/8	.876	.875
3	3.015	2.985	3/16	.1875	.1870	1	1.001	1.000
3	3.015	2.985	1/4	.2500	.2495	1	1.001	1.000
3	3.015	2.985	5/16	.3125	.3120	1	1.001	1.000
3	3.015	2.985	3/8	.3750	.3745	1	1.001	1.000
3	3.015	2.985	1/2	.5000	.4995	1 1/4	1.251	1.250
3	3.015	2.985	5/8	.6275	.6245	1 1/4	1.251	1.250
3	3.015	2.985	3/4	.7500	.7495	1 1/4	1.251	1.250
4	4.015	3.985	1/4	.2500	.2495	1 1/4	1.251	1.250
4	4.015	3.985	5/16	.3125	.3120	1 1/4	1.251	1.250
4	4.015	3.985	3/8	.3775	.3770	1 1/4	1.251	1.250
4	4.015	3.985	7/16	.4375	.4370	1 1/4	1.251	1.250
4	4.015	3.985	1/2	.5000	.4995	1 1/4	1.251	1.250
4	4.015	3.985	5/8	.6250	.6245	1 1/4	1.251	1.250
4	4.015	3.985	3/4	.7500	.7495	1 1/4	1.251	1.250
4	4.015	3.985	7/8	.8750	.8745	1 1/4	1.251	1.250
5	5.015	4.985	1/2	.5000	.4995	1 1/4	1.251	1.250
5	5.015	4.985	5/8	.6250	.6245	1 1/4	1.251	1.250
5	5.015	4.985	3/4	.7500	.7495	1 1/4	1.251	1.250
6	6.015	5.985	3/8	.3750	.3745	1 1/4	1.251	1.250
6	6.015	5.985	1/2	.5000	.4995	1 1/4	1.251	1.250
6	6.015	5.985	5/8	.6250	.6245	1 1/4	1.251	1.250
6	6.015	5.985	3/4	.7500	.7495	1 1/4	1.251	1.250
6	6.015	5.985	7/8	.8750	.8740	1 1/4	1.251	1.250
6	6.015	5.985	1	1.0000	.9990	1 1/4	1.251	1.250
8	8.015	7.985	3/8	.3750	.3745	1 1/2	1.501	1.250
8	8.015	7.985	1/2	.5000	.4995	1 1/2	1.501	1.500
8	8.015	7.985	5/8	.6250	.6245	1 1/2	1.501	1.500
8	8.015	7.985	3/4	.7500	.7495	1 1/2	1.501	1.500
8	8.015	7.985	1	1.0000	.9990	1 1/2	1.501	1.500

All dimensions in inches.
Side teeth are not cutting teeth.
Construction optional with cutter manufacturer.

Since its organization, two standards have been completed and approved by the American Standards Association. These are the Tentative American Standard for Key Slots, Their Bolts, Nuts, Tongue, and Cutters, approved March, 1927, and the American Standard for Tool Holders, Tool-Holder Shanks, and Tool-Post Openings, approved April, 1929. In addition to the two standards which have been approved and the two proposals which are given below, the Committee is developing those for Machine Tapers; Spindle Noses and Collets for Machine Tools, Designa-

Small Tools and Machine Tool Elements

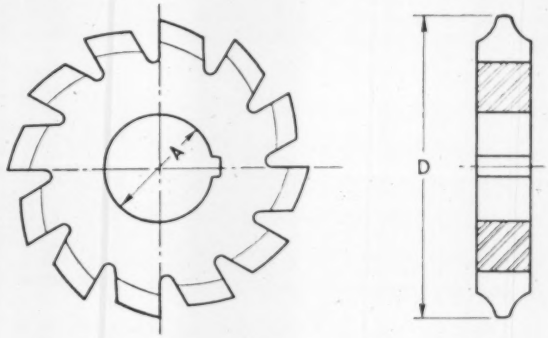


Table No. 1 Involute Gear Cutters Standard Holes

Diametral Pitch	Diameter of Cutter D			Diameter of Hole A		
	Nom.	Max.	Min.	Nom.	Max.	Min.
*1	8 1/2	8.5625	8.4375	2	2.001	2.000
*1 1/4	7 3/4	7.8125	7.6875	2	2.001	2.000
*1 1/2	7	7.0625	6.9375	1 3/4	1.751	1.750
1 3/4	6 1/2	6.5625	6.4375	1 3/4	1.751	1.750
2	5 3/4	5.8125	5.6875	1 1/2	1.501	1.500
2 1/2	5 3/4	5.8125	5.6875	1 1/2	1.501	1.500
3	4 3/4	4.8125	4.6875	1 1/4	1.251	1.250
4	4 1/4	4.3125	4.1875	1 1/4	1.251	1.250
5	3 3/4	3.8125	3.6875	1 1/4	1.251	1.250
6	3 1/8	3.1875	3.0625	1	1.001	1.000
7	2 7/8	2.9375	2.8125	1	1.001	1.000
8	2 7/8	2.9375	2.8125	1	1.001	1.000
9	2 3/4	2.8125	2.6875	1	1.001	1.000
10	2 3/8	2.4375	2.3125	7/8	.876	.875
11	2 3/8	2.4375	2.3125	7/8	.876	.875
12	2 1/4	2.3125	2.1875	7/8	.876	.875
14	2 1/8	2.1875	2.0625	7/8	.876	.875
16	2 1/8	2.1875	2.0625	7/8	.876	.875
18	2	2.0625	1.9375	7/8	.876	.875
20	2	2.0625	1.9375	7/8	.876	.875
22	2	2.0625	1.9375	7/8	.876	.875
24	1 3/4	1.8125	1.6875	7/8	.876	.875
26	1 3/4	1.8125	1.6875	7/8	.876	.875
28	1 3/4	1.8125	1.6875	7/8	.876	.875
30	1 3/4	1.8125	1.6875	7/8	.876	.875
32	1 3/4	1.8125	1.6875	7/8	.876	.875
36	1 3/4	1.8125	1.6875	7/8	.876	.875
40	1 3/4	1.8125	1.6875	7/8	.876	.875
48	1 3/4	1.8125	1.6875	7/8	.876	.875

All dimensions in inches.
* Cutters not carried in stock, but are made to order.

tion and Working Ranges of Machine Tools, Drill Sizes, Drill Bushings, Punch and Die Holders, Circular Forming Tools and Holders, and Chucks and Chuck Jaws. All of these projects are in various stages of development and will be available as quickly as the individual technical committees release their sections.

The A.S.M.E. Standardization Committee is now giving consideration to these standards for Milling Cutters and Cut and Ground Thread Taps, and it desires to know the wishes of the Society's membership in this connection. Accordingly, it has caused to be reproduced below abstracts of the two proposed standards. Complete copies of these proposals are available and may be obtained for detailed criticism and comment by addressing C. B. LePage, Secretary, A.S.M.E. Standardization Committee, 29 West Thirty-ninth Street, New York, N. Y.

Machine Screw Taps

Cut Thread

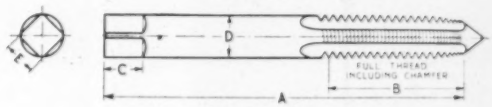


Table No. 1

Size	Threads per Inch		Pitch Diameter			Major Diameter			General Dimensions				
	NC	NF	Basic	Min.	Max.	Basic	Min.	Max.	A	B	C	D	E
0		80	0 0519	0 0524	0 0534	0 0600	0 0610	0 0625	15/64	5/16	3/16	0 141	0 110
1	64		0629	0634	0644	0730	0740	0755	11 11/16	3/8	3/16	141	110
1		72	0640	0645	0655	0730	0740	0755	11 11/16	3/8	3/16	141	110
2	56		0744	0749	0759	0860	0875	0890	13/64	7/16	3/16	141	110
2		64	0759	0764	0774	0860	0875	0890	13/64	7/16	3/16	141	110
3	48		0855	0860	0870	0990	1005	1020	11 13/16	1/2	3/16	141	110
3		56	0874	0879	0889	0990	1005	1020	11 13/16	1/2	3/16	141	110
4	40		0958	0963	0978	1120	1135	1155	17/64	9/16	3/16	141	110
4		48	0985	0990	1005	1120	1135	1155	17/64	9/16	3/16	141	110
5	40		1068	1093	1108	1250	1265	1285	11 15/16	5/8	3/16	141	110
5		44	1102	1107	1122	1250	1265	1285	11 15/16	5/8	3/16	141	110
6	32		1177	1182	1197	1380	1395	1415	2	11/16	3/16	141	110
6		40	1218	1223	1238	1380	1395	1415	2	11/16	3/16	141	110
8	32		1437	1442	1457	1640	1660	1680	2 1/64	3/4	1/4	168	131
8		36	1460	1465	1480	1640	1660	1680	2 1/64	3/4	1/4	168	131
10	24		1629	1634	1649	1900	1925	1945	2 3/64	7/8	1/4	194	152
10		32	1697	1702	1717	1900	1925	1943	2 3/64	7/8	1/4	194	152
12	24		1889	1894	1909	2160	2185	2205	2 3/64	15/16	9/32	220	165
12		28	1928	1933	1948	2160	2185	2205	2 3/64	15/16	9/32	220	165

All dimensions are in inches. All taps have external center on thread end.
Cut thread machine screw taps made according to the above table are regularly furnished with varying number of flutes and length of chamfer. For full information, consult latest trade catalogs.

Milling Cutters

The proposed standard for Milling Cutters was developed by Technical Committee No. 5 after a careful study of the several types of cutters now made by various manufacturers. The Committee functioned through the activity of the following six sub-groups on (1) Nomenclature, (2) Profile Milling Cutters, (3) Formed Milling Cutters, (4) Keys and Keyways, (5) Hobs, and (6) Inserted-Tooth Milling Cutters. The sections of the standards publications corresponding to the first four of the above-named groups have been completed and are now being transmitted by the Sectional Committee to the sponsor organizations for formal approval and transmission to the American Standards Association for designation as American Standards.

The section on Nomenclature is fully illustrated with photographs and classifies milling cutters, based on relief of teeth and also on the method of mounting. Other types of cutters covered in the proposed standard are: formed cutters; involute gear cutters for miter and bevel gears; involute gear cutters, metric sizes; stocking cutters for involute gears; cutters for fluting reamers, cutters for fluting taps and reamers; concave cutters; convex cutters; corner-rounding cutters and sprocket-wheel cutters for roller chains; profile cutters; plain milling cutters, light- and heavy-duty; side milling cutters (straddle mills); half side milling cutters; stagger-tooth metal-slitting saws; single and double angle milling cutters; T-slot cutters; end mills; and shank and shell types.

Keys and Keyways For Milling Cutters and Arbors

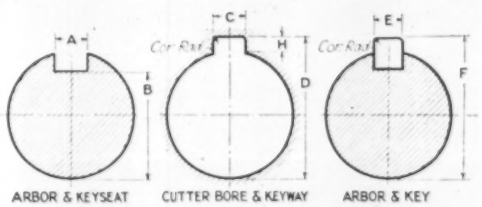


Table No. 1. Keyseat, Keyway and Key Dimensions.

Diam. Arbor	Nom. Width of Key	Arbor and Keyseat				Bore and Keyway[1]					Arbor and Key[1]			
		A Max.	A Min.	B Max.	B Min.	C Max.	C Min.	D Min.	H Nom.	Cor. Rad.	E Max.	E Min.	F Max.	F Min.
1/2	3/32	0947	0937	4531	4181	106	099	5578	3/64	020	0932	0927	5468	5408
5/8	1/8	126	125	5625	5575	137	130	6985	1/16	1/32	1245	1240	6875	6815
3/4	1/8	126	125	6875	6825	137	130	8225	1/16	1/32	1245	1240	8125	8065
7/8	1/8	126	125	8125	8075	137	130	9475	1/16	1/32	1245	1240	9375	9315
1	1/4	251	250	8438	8388	262	255	1 104	3/32	3/64	2495	2490	1 094	1 088
1 1/4	5/16	3135	3125	1 063	1 058	325	318	1 385	1/8	1/16	3120	3115	1 375	1 369
1 1/2	3/8	376	375	1 281	1 276	410	385	1 666	5/32	1/16	3745	3740	1 656	1 650
1 3/4	7/16	4385	4375	1 500	1 495	473	448	1 948	3/16	1/16	4370	4365	1 938	1 932
2	1/2	501	500	1 687	1 682	535	510	2 198	3/16	1/16	4995	4990	2 188	2 182
2 1/2	5/8	626	625	2 094	2 089	660	635	2 733	7/32	1/16	6245	6240	2 718	2 712
3	3/4	751	750	2 500	2 495	785	760	3 265	1/4	3/32	7495	7490	3 250	3 244
3 1/2	7/8	876	875	3 000	2 995	910	885	3 930	5/16	3/32	8745	8740	3 875	3 869
4	1	1 001	1 000	3 375	3 370	1 035	1 010	4 390	5/16	3/32	9995	9990	4 375	4 369
4 1/2	1 1/8	1 126	1 125	3 813	3 808	1 160	1 135	4 953	7/16	1/8	1 1245	1 1240	4 938	4 932
5	1 1/4	1 251	1 250	4 250	4 245	2 285	2 260	5 515	1/2	1/8	1 2495	1 2490	5 500	5 494

All dimensions in inches.
[1]Note: A difference between the overall Cutter Bore and Keyway "D" and the Arbor and Key dimension "F", of .010 inch for Arbor diameters up to 2 inches, and .015 inch on Arbor diameters larger than 2 inches, is allowed.

Cut and Ground Thread Taps

Technical Committee No. 12 on Cut and Ground Thread Taps has also just completed its report, having revised its proposal submitted to industry for general criticism in September, 1929. It will be recalled that this Technical Committee's activity was developed to a large extent by a special committee composed of representatives of large manufacturer and user interests appointed by the National Screw Thread Commission. This special committee, wishing its proposal to be formally approved as an American Standard, suggested that the project be accepted for review by the Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements. The suggestion was accepted by the Sectional Committee and the revised proposal is now submitted to the Sponsors for formal approval with the recommendation that it be submitted to the American Standards Association for approval and designation as an American Standard.

The Proposed Standard

The proposed standard consists of diameter and length dimensions and tolerances for:

(1) Hand taps, cut and ground threads
(2) Machine-screw taps, cut and ground threads
(3) Tapper taps, cut and ground threads
(4) Nut taps, cut and ground threads and
(5) Pulley taps, cut threads.

Test Code for Liquid Fuels

Tentative Draft of a Code in the Series of Twenty-One Formulated by the A.S.M.E. Committee on Power Test Codes

The Main Committee on Power Test Codes takes pleasure in presenting to the Members of the Society the Test Code for Liquid Fuels for criticism and comment. The individual Committee which developed this draft of the Code consists of Messrs. W. J. Wohlenberg, Chairman, E. G. Bailey, B. L. Boye, L. P. Breckenridge, H. W. Brooks, S. B. Flagg, D. M. Myers, S. W. Parr, G. S. Pope, C. R. Richards, E. B. Ricketts, F. M. Rogers, N. Stahl, and E. N. Trump. It is believed that in its present form this Code meets the needs of all groups which from time to time have a part in the making of acceptance tests of this type of apparatus.

In 1918 the Committee on Power Test Codes was organized by the Council of the A.S.M.E. to revise and enlarge the Power Test Codes of the Society published in 1915. This Committee consists of a Main Committee of 25 members under the Chairmanship of Fred R. Low, and 20 individual committees of specialists who are drafting test codes for the various prime movers and the other auxiliary and related apparatus which constitute power-plant equipment.

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections to this draft from those who are especially interested in the production and use of liquid fuels. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Introduction

1 The Test Code for Liquid Fuels is intended primarily to specify standard methods for the determination of those ascertainable chemical and physical properties which serve as indicators of the value of those liquid fuels which are extensively used in the generation of heat and power. As a secondary part of the code are included methods for determining the efficiency of the combustion process itself.

In working out such a code it has been found advisable to adopt codes already in use by other societies. These codes are referred to in the proper place in this code. When some standard of procedure for the A.S.M.E. Code differs from that of some particular part of the code of a sister society which has been adopted, the revision is printed in italics in this code and reference is made to the material which it replaces in the code of the sister society used as the standard method with these exceptions.

Classification

2 For the purpose of this code liquid fuels are divided into the following groups:

A—Distillate Fuels

(1) Volatile products such as gasoline, naphtha, motor benzol, and alcohols, the usefulness of which depends primarily upon ease of vaporization

(2) Semi-volatile products, such as kerosene, kerosene distillates, furnace oil, and tractor fuels, the usefulness of which depends upon volatility but to a lesser degree than in the case of products included in Group 1

(3) Non-volatile products, such as distillate fuel oil and gas oil, the usefulness of which depends upon low viscosity and minimum tendency to form coke or tar in use.

B—Residual Fuels and Blends of Residual and Distillate Fuels

These include petroleum fuel oils, oil tars, and coal tars which are commonly graded in terms of their viscosity into the three general classes:

(1) Low-viscosity oils which can be pumped and atomized at normal atmospheric temperatures

(2) Medium-viscosity oils which can be pumped at normal atmospheric temperatures, but usually require preheating for efficient atomization

(3) High-viscosity oils which usually require preheating both for pumping and atomization.

Specifications

3 The Technical Committee on Lubricants and Liquid Fuels of the Federal Specifications Board has prepared specifications under which fuels are purchased. These specifications have been published by the Bureau of Mines,[1] and will be found useful in cases where it is desirable to designate the type of fuel which is suitable to use in any given type of equipment. The Commercial Standard Specifications for Fuel Oils of the American Oil Burner Association, which were revised as Standard by the Bureau of Standards' Commercial Standards Unit in the General Conference held at New York on January 9, 1929, also will be found useful. The particular province of this code is to define the tests by means of which the properties of fuel are ascertainable, particularly those properties which are of importance in power tests.

Analysis and Tests

4 Liquid fuel may be examined for a variety of properties. Some are of importance for all fuels, while others need be determined only for certain groups of fuels. The various properties may be differentiated also in terms of their practical significance. Some are significant only when the fuels are used for test purposes, while others are useful only in connection with purchase specifications. Still others, of course, are of practical significance in both of these applications.

A tabulation of the various properties, the groups of products for which they are important, and the purposes for which they are most likely to be of practical significance, is given below. The groups of products are indicated by the designations of Par. 2, and the type of usefulness by the letters "T" (signifying power tests) and "S" (signifying purchase specifications).

	Group or groups of products which may be examined for each property (See Par. 2)	Practical significance of property	
A—Calorific Value	All	T	
B—Gravity	All	T	
C—Carbon and Hydrogen Content	All	T	
D—Sulphur Content	All	T	S
E—Ash Content	B-1, B-2, B-3	T	S
F—Water and Sediment Content	A-3, B-1, B-2, B-3	T	S
G—Viscosity	A-3, B-1, B-2, B-3	T	S
H—Distillation Range	A-1, A-2, A-3	T	S
I—Flash and Fire Points	A-2, A-3, B-1, B-2, B-3	T	S
J—Cloud and Pour Points	A-3, B-1, B-2, B-3	T	S
K—Color	A-1, A-2		S
L—Corrosion	A-1		S
M—Acidity	A-1		S
N—Burning Quality in Wick Burner	A-2		S

[1] Technical Paper No. 323-B.

The methods of testing fuels for the various properties listed above are discussed in Pars. 6 to 27, inclusive, of the complete code. Those which go beyond designation of the specifications to employ are given below.

METHODS OF CONDUCTING ANALYSES AND TESTS

6 *A—Calorific Value.* Calorific value shall be stated as "total" heating value.

The calorific value of all liquid fuels, except those in Group A-1, shall be determined by A.S.T.M. Standard Method of Test for Thermal Value of Fuel Oil, Serial Designation D240–27.

7 Volatile products, such as those of Group A-1, present difficulties due to the impossibility of weighing them accurately in open containers. No entirely satisfactory procedure has been developed for these products. The general procedure of Richards and Barry[2] is the most accurate that has been devised, provided a slight modification is made in the method of filling bulbs. Richards and Barry recommend filling by the conventional method of heating and cooling, which obviously is not suitable for complex mixtures of hydrocarbons, although entirely correct for the pure liquids with which they worked. Filling by means of a capillary-tube injector overcomes this difficulty. Another method, which is described by Strong and Stone,[3] involves the use of gelatine capsules, and does not require the special skill in glassworking which is essential with the Richards and Barry method, but it presents other difficulties.

9 It is more or less common practice to calculate the calorific value of petroleum fuels by the use of the formula,[4] B.t.u. = 18,650 + 40 (G — 10), in which B.t.u. signifies British thermal units per pound of fuel and G the gravity of the oil in degrees A.P.I. This formula is not applicable to all petroleum products, but for distillate fuels it yields results which are close approximations, and for volatile products its use is frequently justified by the experimental difficulty of the calorific determination.

10 *B—Gravity.* In the United States it is customary to determine gravity of petroleum products as a function of the ratio between the weights of equal volumes of oil and water, both at a temperature of 60 deg. fahr. (15.56 deg. cent.) with weighings corrected for the buoyancy of air. In actual practice it is most common to determine and report gravity in terms of degrees A.P.I. The relationship between degrees A.P.I. and specific gravity is expressed by the following equation:

$$\text{Deg. A.P.I.} = \frac{141.5}{\text{sp. gr. 60 deg./60 deg. fahr.}} - 131.5$$

Circular No. 154, National Standard Petroleum Oil Tables, Bureau of Standards, contains detailed information regarding gravity determinations and includes directions for the commonly used hydrometer. Several methods which are useful under special conditions are described in Bureau of Mines Bulletin No. 207.

11 Gravity figures are widely used in purchase specifications for petroleum products and are universally *undesirable* in this connection. On the other hand, gravity is an important physical property in the case of power tests as it is frequently desirable to know both the weight and volume of fuel that has been used.

12 *C—Determination of Carbon and Hydrogen in Fuel Oil, Kerosene, Naphtha, and Gasoline.* The apparatus and procedure are the same as those described for the determination of carbon and hydrogen of coal and coke by an electrically heated combustion furnace as given in the Standard Methods of Laboratory Sampling and Analysis of Coal and Coke of the American Society for Testing Materials,[5] with modifications of procedure to prevent too rapid volatilization of the oils. The electrically heated combustion furnace is specified on account of better temperature control than with a gas-heated furnace. The combustion tube should be of fused silica, glazed both inside and outside. To permit observations of the sample, the combustion tube is provided with a 10- to 12-cm. transparent section.

13 *Heavy Fuel Oil.* A sample of approximately 1.2 g. is burned in an open silica boat in the same manner as described for coal and coke in the A.S.T.M. methods, except that more care is required in heating the sample to prevent too rapid volatilization of the oil. The bottom of the boat should be covered with from 15 to 20 g. of black copper oxide powder.

14 *Kerosene, Naphtha, and Gasoline.* These petroleum products are too volatile to be burned in an open boat, so it is necessary to place the sample in a glass bulb having a constricted neck. The glass bulb is weighed empty and 0.10 to 0.15 g. of the oil is introduced by means of a small wash bottle provided with a capillary delivery tube which can be inserted well into the bulb through the opening in the constricted neck. The open end of the neck is then sealed by fusing the tip in a flame, and the capsule plus the sample weighed. The neck of the bulb is scratched with a file and opened, the bulb placed in the boat and inserted into the combustion furnace. The heating unit back of the boat should be *cold* when inserting the bulb into the furnace, and should be kept so until the oil had been almost completely volatilized. The temperature of the heating unit is then slowly raised to a red heat and the unit slowly moved over the sample. Even with careful manipulation an explosion may occur, so the furnace should be covered with a wire screen to protect the operator in case there is an explosion and the tube shattered.

16 *E—Ash Content.* No specific methods have been standardized for determining the ash content of liquid fuels, as the procedure involved permits considerable variation without affecting the accuracy of results. The following procedure will in general be found satisfactory:

17 Thirty to fifty grams of the oil is weighed into a tared platinum dish. Unless the product can be ignited at atmospheric temperature, it is heated cautiously until it will burn and is then set afire. The rate of burning generally slows down after the oil is partly consumed, and when this occurs heat is applied cautiously. After the oil is consumed, the residue is ignited either over a flame or in a muffle furnace until the carbon is completely consumed. The dish is then cooled in a desiccator and weighed. If a platinum dish is not available or if there is any reason to believe the fuel contains heavy metals, a silica dish is employed. A shallow dish or crucible is preferable as it makes it easier to burn out the refractory residue of carbon.

QUANTITY MEASUREMENTS

28 The quantitative measurements of liquid fuels may be based on

(1) Weighed quantity
(2) Direct volume measurement.

Of these, the first method is to be preferred and should be used wherever possible. The measuring device shall in all cases be calibrated. For scales a calibration shall be made both before and after the test.

29 When the second method is used the fuel shall be delivered to the test preferably from a vertical cylindrical tank, the capacity of which has been determined as gallons for each inch of depth. The volume of oil used during the test can then be determined by gaging the tank before and after the test. From this volume and the mean temperature of the oil the volume at 60 deg. fahr. and the weight shall be calculated by means of the National Standard

[2] *Jl. Am. Chem. Soc.*, vol. 37 (1915), pp. 993–1020.
[3] Bureau of Mines Bulletin no. 43 (1912), pp. 26–27.
[4] Sherman and Kropff, *Jl. Am. Chem. Soc.*, 30 (1908), p. 1626.
[5] A.S.T.M. Standards, 1927, pp. 556–560.

Petroleum Oil Tables contained in Bureau of Standards Circular No. 154.

30 The maximum allowable temperature variations shall not exceed the following values:

Volume Measurements:

(*a*) Volatile fuels, 15 deg. fahr.
(*b*) Non-volatile fuels, 25 deg. fahr.

See also "Instruments and Apparatus."

Flue Gas

31 *Sampling.* The standard flue- and exhaust-gas sampler shall consist of a single open-ended iron, copper, or glass exploring tube of 1/4 to 3/4 in. diameter and of which the open ends are placed at such positions that the collected sample has a composition representative of the average composition of the gas being sampled. A determination of such positions will require preliminary exploration and judgment. Pockets back of dampers and at bends shall be avoided. For further details see "Instruments and Apparatus."

32 *Temperature.* The thermometer bulb or hot junction or other device used for temperature measurements shall be placed as near the open end of the sampling tube as possible and in such a position that the stream flow impinges freely on the temperature-responsive elements, but of course not so as to interfere seriously with gas flow into the sampling tube. The best form of pyrometer is that known as the suction pyrometer. (See "Instruments and Apparatus.")

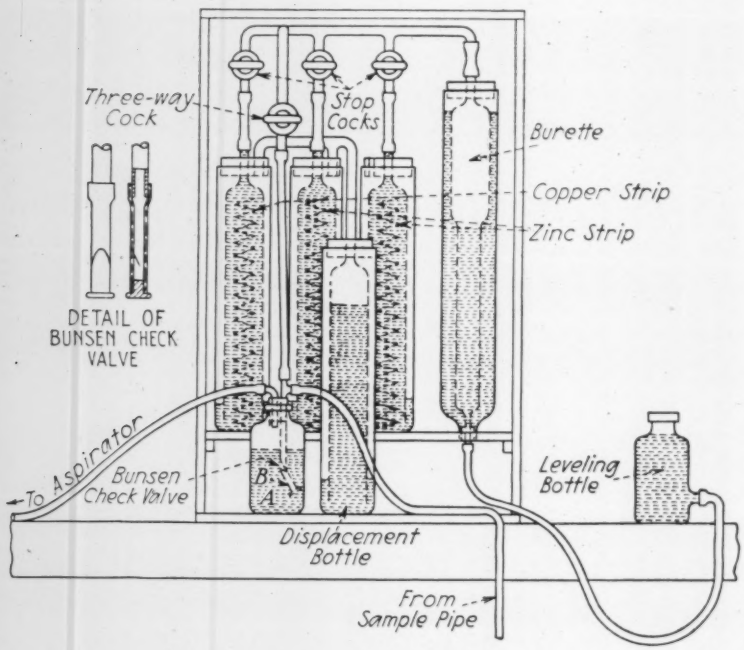


FIG. 1 ORSAT FLUE-GAS-TESTING APPARATUS

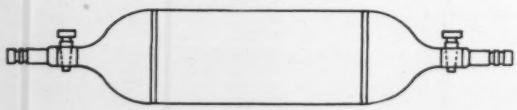


FIG. 2 GLASS CONTAINER FOR COLLECTING GAS SAMPLES

(When the gas is at a pressure below normal, it may be drawn in by an aspirator. When, however, it is under pressure above normal, it will readily displace the water in the container.)

33 The thermometer or hot junction must be protected from radiation to colder or hotter surfaces which may be in the vicinity, by providing metal, asbestos, or other shields so placed in the gas stream that no direct radiation can take place between the bulb or hot junction and the hot or cold surface.

Collecting Flue- and Exhaust-Gas Sample

34 The gas sample shall be carried from the sampling pipe (Fig. 1) in a single tube to the bottle *A* for separating of condensed moisture and tars. This bottle contains a Bunsen check valve through which gas may be continually aspirated by means of a steam or air aspirator. The aspirating process shall be strong, continuous, and at a uniform rate. When it is desired to take the sample, the sample line shall be purged by means of the aspirator. The three-way cock is then manipulated to draw the gas sample into the header and burette and push it out again to atmosphere by means of the leveling bottle. This insures that the header and connections are all completely filled with a fresh sample of gas. The sample itself is then drawn into the burette and the excess pushed back out through the atmospheric vent of the three-way cock.

34*a* The pipettes shall have metal strips bent zigzag fashion as shown, or shall contain glass tubes to offer surface for the absorption of the gas. The oxygen and CO pipettes shall preferably be connected to a glass tee which is connected to a fourth pipette for sealing the solution in the pipettes from the atmosphere. When it is impractical to install the fourth pipette as shown, the oxygen and CO pipettes shall each be connected to their own rubber sealing bottles. If water is used in the bottle *A* it shall be saturated with the gas being analyzed, or concentrated brine may be used.

35 It is preferable to have the flue- or exhaust-gas sample drawn directly into the gas-analyzing apparatus as shown. When this is not feasible the sample may be collected in standard 2-liter collecting bottles connected to the discharge from the bottle *A* containing the Bunsen check valve, or glass tubes such as are shown in Fig. 2 may be used in place of the standard collecting bottles. For a more complete description see the chapter on exhaust-gas analysis of "Instruments and Apparatus." The gas sample may be collected in quantities proportioned to the rate of burning fuel, or they may be collected in equal quantities at equal intervals of time. In the latter case the average analysis of the gases must be arrived at by weighing the separate determinations proportionally to the weights of fuel burned during the times of collecting the samples from which the analyses are made. Whenever possible the analysis shall be made immediately after collection of the sample.

Flue-Gas Analysis

36 In general, gas samples collected in the manner described above shall be analyzed for CO_2, CO, and O_2 by means of an Orsat apparatus. When more than 0.5 per cent of CO is present the carbon monoxide shall be removed with two cuprous chloride pipettes. When hydrogen and hydrocarbons are to be separated out, the modified Orsat, much as devised by Col. G. A. Burrell and known as the Burrell gas-analyzing apparatus, shall be used. In place of mercury a saturated salt solution may be used in the leveling tube. For a more complete description of this apparatus and the method of its manipulation, see the section on exhaust-gas analysis of "Instruments and Apparatus." For more detailed information on flue-gas analysis see Part 10, Chemical Composition of "Instruments and Apparatus."

Engineering and Industrial Standardization

Standard Dimensions for Limit Gages

WITHIN a month or so the U. S. Government Printing Office will issue as a printed pamphlet the report of the American Gage Design Committee. This report recommends a series of standard dimensions for plain cylindrical plug-gage blanks and handles, thread plug-gage blanks and handles, plain ring-gage blanks, and thread ring-gage blanks.

In 1920 the A.S.M.E. accepted sponsorship for the Standardization of Plain Limit Gages for General Engineering Work under the procedure of the American Standards Association. It immediately set about organizing a sectional committee to undertake the development of this project and the formulation of proposed American Standards in this field. The Sectional Committee held its organization meeting in June, 1920, and three subcommittees were appointed to deal with the following three phases of the subject: (1) Tolerances, Allowances, and Gages for Metal Fits; (2) Methods of Gaging and Specifications for Plain Limit Gages; and (3) Gages, Their Limits, Manufacture, and Use. Col. E. C. Peck was elected Chairman of the Sectional Committee, G. T. Trundle, Chairman of Sub-Committee No. 1, F. O. Hoagland, Chairman of Sub-Committee No. 2, and Prof. Earle Buckingham, Chairman of Sub-Committee No. 3.

Sub-Committee No. 1 held eight meetings during 1920 to 1924, inclusive, and finally completed its report on Tolerances, Allowances, and Gages for Metal Fits. After approved by the sponsor society this proposal was presented to the Standards Council of the A.S.A. and received official recognition as an "American Tentative Standard" in December, 1925.

It was during the activity of this Sectional Committee and its sub-committees that in December, 1926, Col. J. O. Johnson called together a group of manufacturer and user representatives at the A.S.M.E. headquarters to consider the advisability of attempting to simplify gaging practice through the adoption of standard designs for gage blanks and component parts. The result of this conference was the organization of an informal committee. At a subsequent meeting it decided on "American Gage Design Committee" as its name, and elected a technical sub-committee.

Twelve meetings of the American Gage Design Committee were held during the years 1927, 1928, and 1929, generally at the time and place of the meetings of the National Screw Thread Commission. These meetings were well attended by the members of the Committee and other interested persons. All the manufacturers of limit gages and representatives of many large users cooperated to the fullest extent with the Committee and two of the former waived patent rights to permit the Committee to include in its report and recommendations the best present American practice in the design and construction of plug and ring limit gages, both plain cylindrical and screw-thread.

The names of the members of the American Gage Design Committee are listed below. Those which are starred are also members of the Technical Sub-Committee:

*Col. J. O. Johnson, *Chairman*, Chief, Gage Section Ordnance Department, Washington, D. C.
H. W. Bearce, *Secretary*, Bureau of Standards, Washington, D. C.
J. Chester Bath, Vice-President, John Bath & Co., Worcester, Mass.
F. J. Benesch, Western Electric Co., Inc., Chicago, Ill.
F. S. Blackall, Jr., Vice-President and General Manager, the Taft-Peirce Manufacturing Co., Woonsocket, R. I.
*E. J. Bryant, Manager, Gage and Reamer Depts., Greenfield Tap and Die Corporation, Greenfield, Mass.
*A. C. Danekind, Manager's Office, General Electric Co., Schenectady, N. Y.
A. H. d'Arcambal, Pratt & Whitney Co., Hartford, Conn.
*W. H. Gourlie, Gage Division, Pratt & Whitney Co., Hartford, Conn.
A. Grieves, Chevrolet Motor Co., Flint, Mich.
P. M. Herrick, Cadillac Division, General Motors Corporation, Detroit, Mich.
H. D. Hiatt, Nash Motors Co., Racine, Wis.
C. V. Johnson, Sales Engineer, The John-Sons Gage Works, Hartford, Conn.
*H. S. Kartsher, Cleveland Heights, Ohio
C. B. LePage, Assistant Secretary, A.S.M.E., New York, N. Y.
*H. B. Lewis, Brown & Sharpe Manufacturing Co., Providence, R. I.
A. M. Lord, Taylor Instrument Cos., Rochester, N. Y.
*L. M. McPharlin, The Studebaker Corp., South Bend, Ind.
*P. V. Miller, Manager, Small-Tool Department, The Taft-Peirce Manufacturing Co., Woonsocket, R. I.
*D. W. Ovaitt, *Chairman* of Technical Sub-Committee, Efficiency Engineer, General Motors Corp., c/o Buick Motor Co., Flint, Mich.
Louis E. Peck, General Manager, The Threadwell Tool Co., Greenfield, Mass.
Charles M. Pond, Manager, Small-Tool and Gage Division, Pratt & Whitney Co., Hartford, Conn.
C. H. Reynolds, The Sheffield Machine and Tool Co., Dayton, O.
P. D. Ritchey, The Standard Gage Co., Poughkeepsie, N. Y.
C. E. Rundorff, Research Engineer, Buick Motor Co., Flint. Mich.
*A. W. Schoof, Chief, Tool Inspection Division, Western Electric Co., Hawthorne Station, Chicago, Ill.
J. A. Siegel, Packard Motor Car Co., Detroit, Mich.
O. J. Snider, Cadillac Motor Car Co., Detroit, Mich.
H. B. Stringer, Winter Bros., Wrentham, Mass.
H. L. Van Keuren, The Van Keuren Co., Watertown, Mass.
*C. E. Watterson, Sheffield Machine and Tool Co., Dayton, O.
*W. H. Weingar, West Hartford, Conn.

Standing Committee

Col. J. O. Johnson, *Chairman*, Ordnance Department, U. S. Army
F. S. Blackall, Taft-Pierce Manufacturing Co.
E. J. Bryant, Greenfield Tap and Die Corp.
C. R. Burt, Pratt & Whitney Co.
A. C. Danekind, General Electric Co.
C. B. LePage, The American Society of Mechanical Engineers
D. W. Ovaitt, General Motors Corp.

Vacuum-Tube-Base Dimensions and Arrangement

A NATIONAL standard for radio-tube bases has just been formally approved by the American Standards Association following the preparation of the standard by a technical committee under the chairmanship of Dr. Alfred N. Goldsmith, vice-president of the Radio Corporation of America. This is the first authoritative national standard for radio equipment. The Institute of Radio Engineers and the American Institute of Electrical Engineers are playing a leading part in the work.

The standard provides that the large pins of the tube bases shall be 0.156 in. in diameter, and the small pins 0.125 in. in diameter. This applies to both the large and small types of tubes. The standard also provides that the diameters of the pins must not be more than 0.003 in. larger or smaller than the normal. Standards are also set up for the dimensions of the bases and the position of the pins. The large pins, it is stipulated, shall connect with the filament. The standard states which small pin shall connect with the plate, and which with the grid.

Nineteen national organizations are represented on the radio committee which is preparing unified national standards for radio apparatus under the auspices of the A.S.A.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division

A. L. KIMBALL, JR.,
Applied Mechanics Division

H. W. BROOKS,
Fuels Division

R. L. DAUGHERTY,
Hydraulic Division

WM. W. MACON,
Iron and Steel Division

JAMES A. HALL,
Machine-Shop Practice Division

CHARLES W. BEESE,
Management Division

G. E. HAGEMANN,
Materials Handling Division

J. L. WALSH,
National Defense Division

L. H. MORRISON,
Oil and Gas Power Division

W. R. ECKERT,
Petroleum Division

F. M. GIBSON and W. M. KEENAN,
Power Division

WINFIELD S. HUSON,
Printing Industries Division

MARION B. RICHARDSON,
Railroad Division

JAMES W. COX, JR.
Textile Division

WM. BRAID WHITE,
Wood Industries Division

Fuels

Acid-Erosion Inhibition

F-13 In unlined steel stacks, flues, and breechings operating up to capacity, what methods have been used to inhibit acid erosion where high-sulphur coals are burned, and what results in increased life have been attained?

The writer's company has specialized in the building of steel stacks combined with induced-draft apparatus over a period of 5 years in the United States and approximately 30 years in Europe. It was felt that it would be of interest to have the opinion of Emile Prat, due to the fact that his observation extends over the long period of time mentioned above, and covering approximately 7000 installations.

Mr. Prat states that as regards early Prat stacks which were built before 1900, there has been very little occasion to replace the diffuser portion because of corrosion from acid gases. He cites, for example, the stacks at the factory where the Citroen automobiles are manufactured, which were installed in 1898 and are still in service without replacement. This condition may be due to the following causes:

a The stacks are, in general, comparatively short and the gas does not have the opportunity of cooling to the dew point, as would be the case with a taller steel stack.

b The amount of sulphur in the coal in France ranges, in general, from 0.5 to 1 per cent, although in the South of France the sulphur runs as high as from 3 to 5 per cent.

c In the installations made 25 or 30 years ago the gases in general were not cooled to as great an extent as they are at the present time, due to the more general use of air heaters.

The fact that the stack itself is short, and that the temperature does not drop appreciably from the time the gas leaves the fan until it issues from the stack is undoubtedly of considerable importance, since tests have indicated that there is a drop of approximately 1 deg. fahr. for each three feet of stack, and that the difference in the temperature along the outside of the current of gas, compared with the center, is from 4 to 5 deg. fahr.

Mr. Prat's observation is of particular interest, due to the fact that the thickness of the diffusers used in Europe is considerably less than that customarily employed in the United States, ranging between 0.15 in. and 0.28 in. Corrosion which has occurred is noticeable in the top section of the stack, but not in the lower section. The condition was considerably aggravated during the World War for plants which were shut down, but with continuous operation corrosion does not, apparently, attack the interior of the stack, but more particularly the exterior if this is not protected by a coat of tar paint every eighteen months.

He concludes that, provided the temperature is not less than 300 deg. fahr., no precaution beyond the outside painting mentioned is necessary.

It is of further interest to note that air heaters which have been in operation at the Gennevilliers Central Power Station of the City of Paris were examined last month, and it was found that after seven years of continuous operation no corrosion whatever was noticeable upon the plates. Since the temperature of the plates in an air heater is approximately the mean temperature between the air and the gas at any given point, this result over a long period of years is of considerable interest, for the actual plate temperature would be lower than the temperature of the ducts after the air heater, which latter were not subjected to a rapid circulation of air about them.

Observation in the United States has been made upon "Thermix" stacks built of copper-bearing steel, wrought iron, and ordinary steel, and during the five years since these stacks have been generally used in the United States, no relative corrosive effect could be noticed with the different types of metal employed in their construction. (Louis C. Whiton, Jr., President, Prat-Daniel Corporation, New York, N. Y.)

Miscellaneous

Solidified Carbon Dioxide, the New Refrigerant

M-9 What are the most common sources of the carbon dioxide used in the manufacture of solidified CO_2 for refrigeration purposes?

A period of only about four years has elapsed since solidified carbon dioxide entered the field of commercial refrigerants. It has since established its excellent qualification for low-temperature work, because of the cleanliness of its refrigerating process, light weight, and small bulk. It sublimates directly into the atmosphere without a trace of moisture, odor, corrosion, or any other offensive or destructive consequence.

Its latent heat of sublimation as measured by Behn is 256.3 B.t.u. while Maass and Barnes state it to be 246.4 B.t.u., to which must then be added the superheat of the vapor between —109 and 0 deg. fahr., which totals 28.7 B.t.u. when the average specific heat is taken at 0.19, so that the final refrigerating effect of 1 lb. of solid CO_2 will then be 246.4 + 28.7 or 275.1 B.t.u.

This in itself is not particularly startling, since it hardly represents twice the latent heat of water ice. However, it possesses another characteristic, at first little understood, namely, the excellent insulating property of its vapor, which is stated to be twice as effective as the non-conductivity of air. Moreover the vapor generated during the sublimation of this refrigerant is of low temperature and of considerable density so that heat from the outside penetrates it but slowly. Hence when perishables are enveloped in a continuously self-replenishing jacket of vapor or gas, heat influx is so thoroughly retarded that the total heat absorption plus the heat resistance of the medium is easily ten times more effective than the latent heat of water ice. To this should also be added many other favorable characteristics of solid CO_2, which in the sum total place the method in which it is used far in the lead of any other known and practical one.

The application of solid CO_2 at present is limited in scope on account of its comparatively high cost, which in spite of its acknowledged superiority over other refrigerants prevents a more universal use for general refrigerating purposes. It is therefore necessary to find means whereby this medium may be changed into the solid state and so reduced in cost that other fields must come automatically within its sphere of usefulness.

This desirable condition can be reached along two roads, the first of which is the perfection of mechanical means to effect solidification, and the second pertaining to the abundant sources from which pure CO_2 gas may be obtained. Engineering ingenuity has already accomplished much in reducing the cost of changing the state of CO_2. The first crude method consisted in taking prepared liquid CO_2 and reducing it into a solid by evaporation. The wastefulness of this method will easily be appreciated when it is considered that liquid CO_2 of 80 deg. fahr. must give up 75 per cent of its weight by evaporation to change the remaining 25 per cent into a solid which at atmospheric pressure has a temperature of —109 deg. The pressure-total-heat diagram shows this vividly in the following manner. The available heat per pound of liquid CO_2 at 80 deg. is only 64 B.t.u., while the total heat of sublimation from the solid has in it a minimum of 246 B.t.u. Therefore, in order to store up this total heat in one pound of the solid it requires 246/64 or 3.84 lb. of liquid per pound of the solid. Expressed in energy it has been found that it requires approximately 0.2 hp-hr. to produce 1 lb. of solidified CO_2. (J. C. Goosmann, Engineering Division, Ice and Refrigeration Dept., Frick Co., Waynesboro, Pa.)

Questions to Which Answers Are Solicited

BENDING A HEAVY I-BEAM

M-3 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft. 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

CONVEYING SAND HYDRAULICALLY

M-10 It is planned to convey sand from a washer to a height of 20 ft. above the washer by means of water injected at high velocity through a nozzle into a 5-in. pipe. Does this arrangement seem feasible, or will the quantity of water to be disposed of offset the advantages gained by the elimination of mechanical apparatus?

LEAKY BOILERS FOLLOWING USE OF WATER SOFTENERS

P-3 A user reports leaky seams and rivets following the use of softened feedwater. What may be the cause of this and what remedies are suggested?

Correspondence

Aircraft for Passenger Transport

TO THE EDITOR:

The writer has read with much interest the paper "Aircraft for Passenger Transport," by Mr. Charles N. Monteith, Chief Engineer of the Boeing Aircraft Company, which appeared in the August issue of MECHANICAL ENGINEERING.

The Boeing Company has made so excellent a record in the development of aviation that the opinions and writings of the men composing that capable organization must command attention and thought.

Naturally the writer was particularly interested in Mr. Monteith's remarks on the subject of reducing noise and vibration. It is generally admitted, he believes, that until a really comfortable degree of quiet is actually obtained in the passenger plane, the air lines have a real obstacle to the much wider development of passenger traffic in the discomfort of excessive noise. In people not accustomed to it, *continuous* noise in excess of about 65 sensation units generally sets up nervous irritation after awhile. Below 60 sensation units, however, no physical objection exists, and conversing or sleeping in comfort, business transaction, and radio or other entertainment (and without megaphone), which latter Mr. Monteith properly considers a most valuable factor in popularizing and increasing air travel, are easily possible.

As one who has specialized on this particular improvement of the cabin plane, the writer wonders if he may with propriety somewhat enlarge on Mr. Monteith's remarks in this respect, and in one detail offer a correction?

In the first place, it would seem well to bear in mind that—as Mr. Monteith indicates—most of the objectionable noise is not caused by the engine exhaust. Competent estimates ascribe about 30 to 25 per cent to the engine, and 70 to 75 per cent to air sources such as propeller slap, strut whine, wing roar, etc.—if the writer may be pardoned for possibly coining one or two descriptive phrases. Really competent sound deadening of the cabin wall therefore seems to be the only proper antidote.

Realizing this, the cabin-plane manufacturers for some years lined their cabin walls with half an inch or so of various absorbing materials. This was an improvement, but how far toward the desired degree of quiet comfort it brought them was perhaps rather clearly indicated in the actual flying tests made last spring by the Sound Laboratory of the Bureau of Standards.

After seven or eight months of elaborate tests in the laboratory, one treatment for the cabin wall was found that had at once an extremely high deadening effect and yet met the strict necessity for minimum weight—it was, the writer thinks, about three times as light as the next best.

A large cabin plane (three-motored) was borrowed from another branch of the Government. The large cabin was divided in two by a bulkhead with a small door. One half of the cabin, including the bulkhead (but not the floor), was then given the treatment mentioned above: a course of 2-in. Dry-Zero Aeroplane Blanket, a very thin covering of pulp board, another course of 2-in. Dry-Zero, and finally the ordinary interior fabric. The other half of the cabin retained its previous half-inch of another sound-deadening material, and interior fabric.

Flights under normal conditions were then made. It was found that in the well-treated portion of the cabin, conversation in ordinary tones was perfectly satisfactory even when the speakers were 10 ft. apart; the instruments showed about 57 sensation units.

In the portion of the cabin with 1/2 in. of acoustic material it was found very difficult to understand another person at a distance of a foot or two, even though speaking in excessively loud tones; the instruments showed about 75 sensation units.

It is illuminating to know that the ordinary business man's office shows about 60 sensation units.

The result of these actual-condition flying tests by the Bureau of Standards is rapidly being applied, and with various modifications. Indeed, great success has been obtained with a single course of 2 1/2 in. of the same material, without the thin pulp board. The "graining" or paralleling of the intensely fine closed tubular fibers, of which this material is made, seems to add materially to its efficiency in sound absorption, and is also responsible for its extremely high efficiency as a heat-insulating material.

The question of weight is of course vital. Dry-Zero's lightness is most graphically indicated by saying that it has only one-seventh the weight of cork! The 2-in. Aeroplane Blanket weighs about 3 1/3 ounces per square foot, and the 2 1/2-in. but half an ounce more.

Mr. Monteith classifies Dry-Zero as a "wood fiber." This is only true in so far as it is a tree product. But it is a whole (and tubular) fiber which grows in the pod of the ceiba or silk-cotton tree, and attached to the seeds. Its extraordinary lightness and aversion to moisture are the results of Nature's uses for it: first to protect the extremely sensitive seed from sudden changes of temperature—from the radiance of the tropical sun to the cool of evaporating rain, and secondly to carry the seed for propagation at distances, through the tropical showers.

The correction the writer wishes to offer is that while Mr. Monteith is quite correct in saying "all of the wood-fiber materials quickly absorb moisture," his error in classifying Dry-Zero as one of them leads to a misapprehension. This material (except the excessively light muslin covering) is extremely repellent to moisture—one of the most repellent in the entire vegetable kingdom. It has been shown that it will float for years on water, in a closed vessel, without being in any way affected. So strongly does it repel moisture that the U. S. Navy and many others use this fiber for life jackets, buoys, etc., and in consequence it is peculiarly adaptable for airplanes in that respect also.

HARVEY B. LINDSAY.[1]

Chicago, Ill.

Fundamentals of Management as Applied to Industrial Enterprises

TO THE EDITOR:

The writer has read Mr. Alford's lecture on the fundamentals of management as applied to industrial enterprises, in MECHANICAL ENGINEERING for October, with particular interest because of his own work on this problem.

Feeling certain that the true analysis of the management function requires a practical measurement and rating of the various phases, it is his contention that the problem of obtaining the true fundamentals is closely allied to the problem of measuring and rating management which Prof. Joseph Roe brought up at the Society's 1923 sessions.[2] Any method based on scientific analysis to improve an industrial enterprise requires the quantitative tool to measure the elements of the management functions. Mr. Alford's laws of manufacturing, and Dr. Kimball's fundamentals, do not have in them such a tool for rating mangement, and for this reason their principles cannot be practically applied in the specific case. From the very nature of their presentations it is apparent that these authors simply intend to call attention to the importance of their principles in industrial organization.

The writer wishes to call to the attention of the members of the A.S.M.E. the extreme importance of the analysis, from the operating point of view, of this problem of securing the true fundamentals. Such an analysis results in policies of operation for which standards, based on the particular plant's facilities, may be set. This is evident from his own analysis of the operating point of view which was published last August in the *Bulletin* of the Taylor Society. Such a method gives the following characteristics for the management functions:

1 The standards represent the maximum utilization of the facilities of the plant.

2 The ratings on the basis of these standards indicate the character of the management as well as the possibility of improving the results accomplished.

3 The standards allow for the economic coordination of all phases of management.

4 The growth of standards as reflected by the facilities, equipment, etc., allows for sales policies based on changing conditions. Leadership on the growth of standards practically places in effect a broad ideal of industry's being a tool for ever increasing standards for the benefit of the consumer.

These characteristics and the many other advantages obtained indicate that the analysis from this viewpoint is the only means of getting at the practical fundamentals of scientific management.

GEORGE G. BERGER[3]

New York, N. Y.

TO THE EDITOR:

Mr. Berger opens his letter by stating that he has read my lecture on "The Fundamentals of Management as Applied to Industrial Enterprises," as reported in MECHANICAL ENGINEERING for October, 1929, because of his own work on this particular problem. He then refers to his own paper which was published in the August, 1929, issue of the *Bulletin* of the Taylor Society under the title "A Method of Measuring and Rating Management." He then goes on to say that the fundamentals or laws of manufacturing management which I presented to The American Society of Mechanical Engineers in a paper entitled "Laws of Manufacturing Management" in December, 1926, "do not have in them such a tool for rating management, and for this reason their principles cannot be practically applied in the specific case," and, further, he credits me with the intention simply "to call attention to the importance of their principles in industrial organizations."

If I interpret Mr. Berger correctly, he contends tnat his ratios of various factors in industrial operation are "true fundamentals" rather than the principles which have been developed and declared for more than a quarter of a century, and which have been statements of cause and effect or of major trend. It seems to me that this contention is not well founded, for Mr. Berger's ratios yield a percentage which might be taken as a standard, but can hardly be characterized either as a true fundamental, or law, in any common use of the latter terms.

In a comprehensive approach to the working information on industrial management there is a trilogy of elements: accepted practice; principles or laws; means of measuring results. The above order in which these elements are arranged is the one which I personally have followed. In 1924 there was issued a codification of management practice in the form of "Management's Handbook;" in 1926 I presented a professional paper to the Society

[1] President, Dry-Zero Corporation.

[2] Trans. A.S.M.E., vol. 45 (1923), p. 825.

[3] Industrial Engineer. Mem. A.S.M.E.

on "Laws of Manufacturing Management;" in 1928 Mr. Joshua E. Hannum and I presented a professional paper to the Society under the title "A Basis for Evaluating Manufacturing Operation." This latter development, the kilo man-hour method of analyzing industrial operation, is in the field of investigation which Mr. Berger has undertaken, rather than the formulation of laws and fundamental principles to which he has referred.

That is, while I concur with him as to the extreme importance of analyzing results from an operating point of view, and to the present need of accepted means for analyzing and comparing operating results, I do not believe that such methods, units, or resulting standards are properly classified as the kind of "fundamentals of management" which he has indicated in his letter. Furthermore, in his paper before the Taylor Society he repeatedly refers to his disclosure as a "method of rating."

L. P. ALFORD.[4]

New York, N. Y.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 630-636, inclusive, as formulated at the meeting on September 20, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 630

Inquiry: Is it permissible to rivet cast-iron nozzles to the shells or heads of steam drums or purifiers to be installed ahead of the boiler stop valve, this construction to be limited to operating pressures less than 250 lb. per sq. in., and steam temperatures not exceeding 450 deg. fahr.? If it is not permissible up to these limits, to what limits of pressure and temperature may this construction be employed?

Reply: A steam drum or reservoir connected to a boiler without any intervening stop valve will be classified for construction requirements as a part of a steam boiler and the provisions of Par. P-12 must therefore apply.

CASE NO. 631

Inquiry: Is it the intent of Par. P-230*a* of the Code that the factor *W* in the formula, referring to extreme distance between supports, should refer to the points of bearing of the crown bar or girder stay; or does it refer to the width of the furnace or combustion chamber?

Reply: It is the intent of the factor *W* in the formula in Par. P-230*a* to refer to the distance between the inside of the tube sheet to the inside of the back connection plate.

CASE NO. 632

Inquiry: Is it not permissible, under the revised Par. U-59 of the Code, to use screwed fittings for pressures up to and including 125 lb. per sq. in.? As the third section of the paragraph is worded, there is no provision made for the pressure of 125 lb.

Reply: As this revision has been worded, it inadvertently omits reference to the working pressure of 125 lb. per sq. in. It is the opinion of the Committee that the last sentence of this paragraph should be corrected to read as follows: "For pressures of 125 lb. per sq. in. or less, a screwed fitting may be used."

CASE NO. 633 (In the hands of the Committee)

CASE NO. 634

Inquiry: Will a water-relief valve, which has several markings of the pressure at which it is set to blow, meet the requirements of Pars. H-51 and H-104 of the Code, provided the adjusting screw has an indicator which points toward several stamped figures corresponding to relieving pressures at which it will operate within a limit of error of five per cent, and the adjusting screw is so designed that the valve cannot be set for a higher relieving pressure than the largest relieving pressure stamped thereon?

Reply: It is the opinion of the Committee that the relief valve described meets the Code requirements. The rules in the Code are not sufficiently explicit to cover this type of valve, and it is the intention of the Committee to so modify the requirements that they will require a relief valve that cannot be set at a higher pressure than the maximum allowable working pressure of the boiler.

CASE NO. 635

Inquiry: Is it necessary to adhere to the requirement in Par. P-265 of the Code for a washout plug in the front head at or about the line of the crown sheet, when this space is obstructed by a smokebox? It is the practice with such firebox-type boilers having return tubes with the smokebox at the front head to place washout plugs in each of the side sheets at or about the line of the crown sheet.

Reply: It is the opinion of the Committee that if washout plugs are located in either side sheet at or about the line of the crown sheet so as to afford convenient access to the crown sheet for purposes of cleaning, the spirit of the requirement in Par. P-265 will be met. Attention is called, however, to the requirements of Par. P-268.

CASE NO. 636

Inquiry: Is it necessary to disregard the relieving capacity of a safety valve mounted on a superheater, if a soot-blower connection is made to a tee inserted between the safety valve and the superheater as is provided for in Case No. 548? It is noted that Case No. 600 requires that the full complement of safety valves be installed on the boiler in case there is a shut-off valve located between a superheater and its safety valve, but it is pointed out that a soot-blower connection will not prevent operation of the superheater safety valve.

Reply: The installation of a soot-blower connection between a superheater and its safety valve, as is provided for in Case No. 548, will not affect the application of the requirement in Par. P-288 of the Code relating to computation of relieving capacity, and the relieving capacity of the superheater safety valve may be included as therein provided.

[4] Vice-President, Ronald Press Co. Mem. A.S.M.E.

MECHANICAL ENGINEERING

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John W. Lieb

JOHN W. LIEB had more friends, in Europe and America, than any one man connected with the electric light and power industry. Each of these friends today has memories of kindness—it may have been just the gracious act of little moment, an incident of an occasional contact; or it may have been the continuing helpfulness and dependability of a big man throughout many years—but such memories of Mr. Lieb will stay with many people for years to come. Of these people, I am one.

As an engineer, Mr. Lieb was a wise coordinator rather than a brilliant designer. His advice or his decision settled many problems for many people in a sane and acceptable way. As an executive, he understood the engineering mind and habit of thought. As an engineer, he had the confidence of executives. There are none too many such men in the world. This one will be missed.

ALEX DOW

An Interpreter

WITH the recent death of Edwin Emery Slosson, science, and particularly the science of chemistry, has lost an eminent publicist. Dr. Slosson had the rare gift of interpretation. His knowledge of science made his writings accurate, and his ability at popularization brought significance of the work of hundreds of technicists to the layman. He enriched by his books and by the "Science Service," of which he was the head, both the average reader, by bringing to him crumbs of wisdom from the table of the savants, and the man of science, by showing him to be a valued contributor to the well-being of mankind. His passing marks an epoch in the interpretation of science.

The philosophic uses of misfortune in the present situation lie in the opportunity which the times have made ripe to continue the development of the layman's scientific education, and to extend it to all fields where science and engineering need sympathetic and intelligent interpretation. In engineering, which is so close an ally to industry and business, there is a particularly profitable field for this kind of service. The special knowledge which engineers seek out with their characteristic diligence is sometimes the basis of a development that affects all civilized nations and establishes new industries and new guarantees of prosperity. Even in its simplest forms it directs the elimination of waste of time and of material and human resources. To keep such knowledge locked up in technical papers and discussions is to miss an opportunity for service and to deny to engineers the first appreciation of their talents. The engineering profession needs a medium and a publicist who will not only popularize it for the layman, but bring it more closely in contact with industry, business, and government.

Section M—A.A.A.S.

ENGINEERING is so closely related to science that an engineering section in an all-inclusive scientific organization is a logical relationship. Section M (Engineering) of the American Association for the Advancement of Science provides a contact with all branches of science by means of which many engineering societies are affiliated with the A.A.A.S.

At the annual meeting of the A.A.A.S., to be held this year in Des Moines, Iowa, Section M will sponsor two sessions on December 30 and hold a joint meeting with Section K (Economic and Social Sciences) on December 28.

Dean R. L. Sackett, of Pennsylvania State College, retiring vice-president of Section M, will deliver an address on "The New Science," in which he will discuss the parallel development of science and engineering and their interdependence. Other papers at this same session will be devoted to topics of interest chiefly to civil engineers. The second session is to be devoted to agricultural problems, and will include papers on the utilization of farm waste and engineering on the farm. The joint meeting with Section K will have, among other features, a symposium on statistics and engineering.

Engineers in the vicinity of Des Moines have a rare opportunity of attending this great gathering of scientists, from which they will derive abundant inspiration and profit by contact with men of vision and achievement.

The Airship Industry

LIGHTER-THAN-AIR craft have added a favorable and important year to their history. Recent flights of the *Graf Zeppelin* to the Holy Land and around the world have shown that the modern dirigible has a distinct place of its own in the system of transportation as it is being evolved today, and that it is not competing with the large planes of the Dornier DO-X type. Public confidence in the practicability of this means of travel, so completely shattered by the accident to the *Shenandoah* some years ago, has been restored by the successes of this year.

The news of the day brings abundant evidence of this. In addition to the splendid achievements of the *Graf Zeppelin*, there has come the news of the trial flights of the great British dirigibles. In this country, the *ZMC*-2, the metalclad dirigible described elsewhere in this issue, has been turned over to the U. S. Navy and has made numerous successful flights. Talk is heard of airship lines to Bermuda and to Hawaii. Most recently has come the ceremony of driving the golden rivet into the first ring of the new 6,500,000-cu. ft. Goodyear Zeppelin at the Akron airship factory and dock, pictured on this month's cover.

There is every reason to believe that this newest dirigible will be far superior to the *Graf Zeppelin*. Its designers have had access to the experience of Zeppelin engineers in addition to their knowledge of American methods of construction. Ample funds guarantee that the new dirigible will be properly built, and that it will not, as was the case of the *Graf Zeppelin*, be limited by hangar dimensions and facilities. With some of our most powerful banking interests backing projects for airship transportation, it is only reasonable to expect that the foundation for the dirigible industry is being laid in this country.

The Outlook for the Steam Motor Car

THE steam motor car, which is a *rara avis* in America, is quite common in Europe, and particularly so in England. In the latter's colonies it is often the only possible conveyance, for there are no gasoline filling stations in the African veldt or the Australian bush. Nevertheless, just why the steam motor car has not made better progress than it has, is still somewhat of a mystery. For passenger traffic the steam automobile has the objectionable feature that the ordinary garage man, who has, as a rule, a very fair knowledge of gasoline engines, knows nothing about steam and carries no spare parts for steam vehicles. A motorist running into trouble, particularly in a less frequented part of the country, would therefore be unfortunate if driving a steam car. A further delaying element in America is the fact that gasoline today is fairly cheap, so that for an ordinary passenger car the saving from the use of a cheaper fuel is apparently not sufficiently material to outweigh other considerations. When it comes, however, to trucks, and still more to buses, the possibilities of the steam engine become well worth taking into account. Judging from an article on steam-truck design as practiced in England, published elsewhere in this issue, it would appear that the engineering of existing steam vehicles in England is quite crude and that the possibilities of steam driving are very far indeed from being fully utilized. Coal or coke fuel, which has to be placed on the grate with a shovel, is of course the crudest imaginable method for operating a motor vehicle. Oil burning, when used, is claimed to be noisy. It is significant that it was also noisy when first used in the United States for house heating, but it has been now practically completely silenced, and if it can be noiseless in house heating there is no reason why it cannot be made so when burning under a vehicle boiler. The possibilities of using pulverized coal are only dimly realized, while the whole engine design seems to be a good deal haphazard and rather antiquated.

The price of gasoline in England is, however, so high that with all their disadvantages steam trucks are quite common there. It would appear, therefore, that steam power could find commercial application in motor trucks in this country if it were seriously taken in hand.

For buses, steam is particularly suitable. Buses have their own servicing, and it would be just as easy to collect a personnel familiar with steam as it is to get one acquainted with gasoline engines. The matter of carrying spare parts in bus servicing is of course extremely simple in so far as steam power is concerned. On the other hand, the cost of fuel is a very substantial item in bus operation, and where the buses have to travel through mountainous country, steam has such clear advantages over gasoline as to make the subject of its application worthy of very serious consideration.

If successful at all, however, the development of the steam motor car will be the result not so much of some new invention as of the application to the problem of road vehicles of those principles of design and operation which have been so highly developed in central-station and locomotive practice.

New Applications of Magnetism

MAGNETISM is of course already one of the most useful factors in modern industrial civilization, as the action of the electric generator and electric motor, which between them represent better than anything else the change of our present civilization from that of the past, are based entirely on magnetic phenomena.

Of late, however, new and important applications of magnetism have been made, with the promise that further great developments in this direction may be justifiably expected. That changes in magnetism could be used to detect irregularities in the structure of ferrous metals has been known for a long time. It was, however, only quite recently that Elmer A. Sperry, President of The American Society of Mechanical Engineers, developed his flaw detector for rails. This apparatus, based entirely on the use of magnetic phenomena, makes it possible to determine flaws in rails very rapidly and efficiently, no matter how deeply located, and may be expected to contribute to the safety of rail transportation. Not only this, but it will give an impetus toward developing methods of testing of other steel products, such as bridge elements, structural materials, etc.

Another somewhat startling application of magnetism is described in an abstract published in the Engineering Survey Section in the present issue. In this case, by repeated changes of magnetic fluxes combined with light tapping, a degree of superhardening was obtained which could otherwise have been secured only by a special heat treatment. This not only contributes materially toward justification of present theories of the structure of ferrous materials, but opens up a vista of great possibilities.

It is too early to say whether we are dealing here with a peculiar phenomenon of purely limited application, or with the first approach to a new realm of technical accomplishment in the field of imparting to metals such characteristics as their engineering applications make desirable. If, however, a magnetic field can effect such changes in the subatomic structure of a metal as to induce superhardening, why may we not expect that other types of magnetic field, such as fields of very great density of lines or of the high-frequency type (and there is earnest work going on with both these types of fields), will either produce in metals properties which are now unknown, or, more likely, will do what we are doing today, laboriously and expensively, by high-temperature heat treatment? And the most interesting part of it is that when some such thing really does come to pass, it will probably be even more wonderful than we dare imagine today.

Army Mechanization

GENERAL NATHAN BEDFORD FORREST once said that "he wins who gits the mostest men thar fustest." The vital importance of mobility and concentration both of men and materiél was amply established during the World War, established in fact to a greater extent than ever before. The attack upon and defense of Verdun showed this more clearly than any instance in any previous war. On the one hand, the Germans were able at a moment's notice to throw enormous forces against what was considered a quiet sector; on the other, the French, who were not at all prepared to defend a forceful attack against that particular point, rapidly and practically at a moment's notice shifted a powerful mass of men, artillery, and ammunition sufficient to stop the progress of the German Juggernaut.

There are two elements that make the matter of mechanizing an army of primary importance today. The first is the necessity for mobility of fighting units to enable rapid concentration

in offense and still more in defense. The other element is that animal transport is unavailable in the quantities required for modern warfare; furthermore, conditions for the use of animal transport are becoming such as to make it less and less attractive.

In past wars the number of men engaged at any one spot was quite limited, and while we still talk about the hordes of Attila and Tamerlane, the fact remains that these hordes at any one war sector numbered in no case more than 100,000 fighters. The limit to the size of an army in the past was the ability to provision it. It could not live off the land if it were too numerous, and the means of transportation were too crude to supply provisions from a distance. In the World War the British at Ypres in Belgium were fed with American wheat, Argentine beef, Australian mutton, and Cuban sugar, and were clothed with American and Indian cotton and Australian wool. With every part of the world contributing to the maintenance of any army, there is no limit to its size, as the World War has shown. But the transportation facilities have to be commensurate. It is because of this that as the war went on the price of horses and mules rose tremendously, and had it not been for the employment of mechanical transport on a vast scale, there would have been a very decided shortage of these useful animals.

Today it is a question not of whether an army should be mechanized, but of how far this mechanization should go; that is, whether the old structure of the army should be maintained with machines replacing animals wherever possible, or whether the whole army structure should be reconstructed to adapt itself to the new mechanical means.

The use of gas is a powerful argument in favor of eliminating the horse and mule completely. Obviously, neither can work properly with a gas mask, and cannot work at all without one. A still more powerful argument for mechanization in the broadest sense of the term is the development of the modern rifle, machine gun, and arms intermediary thereto. There was not a single instance in the World War where a frontal attack on a large scale carried the desired positions without the most exorbitant cost in lives. Machine guns in combination with barbed wire and "pill boxes" make it impossible for ordinary infantry to advance, just as at the dawn of history the javelin and bow made their owners invincible against the less well-equipped enemy.

The prehistoric fighter rapidly developed protection in the form of a shield and (very much later) mail, and this protection proved to be sufficient until powder was invented.

The development of modern weapons has become such as to make it again imperative to resort to the shield or mail, with the difference, of course, that instead of the man's carrying the shield or wearing mail, he is transported in a bullet-proof vehicle, which means tanks.

General Buller, in an article in *Army Ordnance*, points out that in so far as the British army is concerned, the most significant thing to him is not the fact of actual wide adoption of mechanical transport and means of fighting, but the change of attitude toward mechanization among the leading men of the British army, many of whom were either opposed to or very dubious about it some years ago, but who seem to have entirely changed their minds recently.

It is a significant fact that at the recent meeting of the Army Ordnance Association at Aberdeen, the Army staged a little show for the benefit of the Association in which not a single draft animal was seen anywhere. Tanks plowed through the fields dragging guns around, airplanes flew above, laying smoke screens and dropping bombs, the smell of lubricating oil was everywhere, but the traditional beautiful cavalry charge and horseback messengers galloping around were completely absent. The only danger from mechanization lies in the possibility of overdoing it, and replacing in some instances well-known constructions by machinery not sufficiently tested. There does not seem to be much danger of such a possibility, but nevertheless it should not be forgotten that such a thing can happen.

The World Engineering Congress in Japan

WITH a program commencing on October 25 and ending on November 22, the World Engineering Congress held in Tokyo, Japan, exceeded the expectations of the delegates. The technical program commenced on October 30 and was completed on November 7. During this period more than 800 papers were presented by engineers from the entire world on a variety of subjects which included every phase of engineering. To this program many distinguished American engineers contributed, including a goodly number who are members of the A.S.M.E. The present issue of MECHANICAL ENGINEERING contains two of these contributions. In connection with the conference there was also held a sectional meeting of the World Power Conference, at which papers of exceptional merit on several subjects pertaining to the economic aspects of power were presented and discussed.

The object of the World Engineering Congress was "to advance knowledge by the presentation of papers and discussions on scientific and engineering subjects, to interchange views on various phases of professional work, to promote international cooperation in the study and application of engineering science, and to cultivate a feeling of fellowship among engineers of the world." Word received from American delegates indicates that these objects were most completely fulfilled. A cablegram received from Tokyo stated that the arrival of the ships bearing the delegates was greeted at Yokohama by unexpectedly large numbers of Japanese, including many of the most distinguished men of the empire.

During the conference, large numbers attended. There was brilliant entertainment by the royalty, nobility, and industrial leaders and engineers. All of the sessions, said the dispatch, were crowded with Japanese engineers and students. The Japanese newspapers cooperated fully and gave front-page accounts of the sessions. Friendliness was evident everywhere, all plants and engineering operations being open to the visitors, including the reconstruction of the city of Yokohama, visited several years ago by a devastating earthquake.

The enthusiasm which typifies the reports reaching this country indicates that the Japanese lived up to their well-known reputation for cordiality and generosity, and that their country and engineering accomplishments both charmed and astounded the visitors.

The World Engineering Congress was held under the auspicies of the Kogakkai, the Japanese Engineering Society, and through the generosity of the Imperial Japanese Government. It was under the patronage of His Imperial Highness Prince Yasuhito of Chichibu. The Honorary President was His Excellency, the Prime Minister of Japan, with His Excellency, the Minister of the Department of Commerce and Industry, the Viscount Eiichi Shibusawa, as Honorary Vice-President. The President was Baron Koi Furuichi, President of the Kogakkai, and the Vice-Presidents were Baron Takumadan, Baron Chuzaburo Shiba, and Baron Takafusa Shijo. The officers of the American Committee were Herbert Hoover, Honorary Chairman, Elmer A. Sperry, President, A.S.M.E., Chairman, and C. E. Grunsky, Frank B. Jewett, C. F. Kettering, John W. Lieb (recently deceased), Vice-Chairmen, Burnett Walker, Treasurer, and Maurice Holland, Executive Secretary. Many members of the A.S.M.E. attended the Conference as official delegates, including Secretary and Mrs. Calvin W. Rice.

An account of the Conference will appear in a later issue of MECHANICAL ENGINEERING, with a critical appreciation of its success.

Rockford, Ill., Meeting of the A.S.M.E. Wood Industries Division

THOSE who think that wood as an engineering material has seen its day and that the wood industries present few engineering problems, should attend one of the national meetings of the A.S.M.E. Wood Industries Division, the fourth of which was recently held at Rockford, Ill., October 16 to 19.

The eleven technical papers presented at this meeting covered the subjects of management, wood bending, glue and coatings, and woodworking machinery. The attendance of well over two hundred was greater than that at any of the previous meetings, and was matched by the enthusiastic response which the excellent papers met with in discussion. On the third day of the meeting more than sixty made an excursion to Madison, Wis., for an inspection of the U. S. Forest Products Laboratory in that city.

It is expected that the next national meeting of the Wood Industries Division will take place somewhere in the East along the Atlantic Coast. This will give an opportunity for many engineers to witness the great progress which engineering is making in this time-honored industry.

Research in the Printing Industry

FROM the engineering standpoint, the International Conference of the Technical Experts in the Printing Industry on the Need for Research, called by the Executive Committee of the Printing Industries Division of the A.S.M.E. at the suggestion of the Research and Survey Committee of the Division, and held under the auspices of the Pittsburgh Local Section at the Carnegie Institute of Technology on November 7 and 8, was an unqualified success.

The industry, through the delegates present—more than 300 in number—was awakened to the realization of the need for research in all its branches: printing, lithographing, photoengraving, electrotyping, and bookbinding; in its raw products of paper and ink and metal; in the manufacture of its machines and appliances; and in its production methods in the divisions of newspaper, book and magazine, and general printing. The practical value of the conference, it may be said, will be determined by the action of the twenty-two national and international associations interested in the graphic arts, every one of which was well represented at the conference, in building up a research fund.

A great graphic-arts research foundation was discussed and was enthusiastically approved by the delegates, and a representative ways and means committee was formed, with permission to expand itself to include every interest, to secure such a fund.

There can be no serious dispute of the assertion that the graphic-arts industries have made tremendous progress and that developments in machinery and in methods represents a type of inventive genius and business acumen not surpassed in any other art or industry. There can be no criticism of the impelling motives behind the efforts which have resulted in the tremendous growth of this all-important industry. Yet at the same time there can be no denial that this development and this progress have been almost entirely due to the independent activities of the various agencies which contribute to and depend upon the graphic-arts industries. Much of the development of the industry may easily be traced to "know-how" methods and to "cut-and-try" inventions. Developments and improvements have been accomplished in many instances without regard to basic requirements and fundamental principles.

That this is a fact was clearly evidenced by the papers presented before the conference. Each of the thirty-three prepared papers and extemporaneous addresses was presented by a recognized authority in his field, and each one reflected thorough knowledge and studious application to one branch of the industry; and yet there could be no doubt of the walls of tradition and the boundaries of prejudice which seemingly have prevented a full realization of their common ambitions. An analysis of the presentments by the various speakers indicates a remarkable unanimity of conviction that further progress of a fundamental nature can be achieved only through basic research embracing all phases and aspects of underlying principles, and through coordination and cooperation of all the allied interests. This lack of cooperation and coordination has been due mainly to the fact that the various branches of the graphic arts are in themselves distinct trade units which have their own interesting and absorbing problems. Each is dependent upon the other, and yet among them there is an absence of joint effort to produce a structure of technical correctness and economic soundness.

The American Society of Mechanical Engineers, as a national association devoted to the furtherance of engineering ideals and of practical performance, has no selfish purpose to serve and no material benefits to be realized. In this conference it has developed the need for that kind of research which other industries have found so necessary and so profitable. It also has assured to the graphic-arts industries the cooperation and the background of knowledge and experience of the organized engineering profession as a neutral agency about which their several branches may crystallize into actuality that unity of purpose and of idealism which long has been felt to be necessary to further progress and the lack of which has retarded development.

Akron Meeting of the A.S.M.E.

AN ACCOUNT of the meeting of the Society at Akron, Ohio, October 21 to 23, appeared in the November 7 issue of the *A.S.M.E. News*. This successful meeting gave an opportunity to engineers to see the great rubber industries which are a source of pride not only to the city of Akron but to the entire country. Aside from the reportorial account already mentioned, certain features of the meeting, it would seem, are worthy of a critical survey.

It is, for instance, surprising that the literature of the A.S.M.E. does not contain more data on engineering in the rubber industry. An examination of the great factories which were opened for inspection gave evidence of many problems and processes of interest to mechanical engineers. Here is an industry in which the chemist, the physicist, and the engineer are jointly interested. Heat plays an important role in the proper manipulation, and hence steam is an important item of expense. The problem of materials handling is especially acute in an industry in which the processes are essentially continuous. This latter fact, too, must introduce some problems of managerial control which have interesting sociological aspects. In addition to these subjects there are the problems involved in training apprentices to a trade which has its own technique and which differs from the more common trades of artificers in metal and wood. The machinery itself is worthy of study and has interesting features for designers of other kinds of machinery to study. It seems reasonable to suppose, therefore, that engineers in the rubber industry, as well as those who are outside of it, can reap mutual benefits

by frequent conferences and joint discussion of their problems. Much might be learned by both groups.

Of the sessions themselves, it is impossible to refrain from calling particular attention to the one devoted to the subject of the elimination of waste in industry. The almost unbelievable savings which were reported by the able engineers who had conducted elimination-of-waste campaigns call sharply to attention the great field which engineers have yet to develop in manufacturing establishments under their control. The problem is essentially one in which human nature plays an important role. It was interesting to note, for instance, that the strenuous efforts expended in these campaigns partook somewhat of the nature of those of revival meetings. The good effects apparently wore off, though not completely, as the interest flagged after the active campaign was over. Leaders in this movement are striving to make the results of their efforts more lasting, and significant progress has been made along this line. It is not too much to hope that, once engineering minds are turned to the solution of this staggering problem of waste, the results will be as fruitful and as consistently uniform as are those which have come from engineering effort expended in other phases of production and management.

The proposal that there shall be some "dictionary" of waste elimination and utilization prepared under the auspices of the Society met with hearty approval and pledges of cooperation. The idea is to make the experiences of engineers the common property of all interested in this field. It is obviously a waste of time and effort for every engineer to evolve for himself uses for his waste materials when others have discovered them elsewhere. With the aid of the proposed "dictionary" an engineer would find under "lumber," for instance, a number of suggested uses and markets for his waste material. Evidence given at the meeting, for example, showed that broken insulator porcelains which had previously been buried at considerable expense in order to get rid of them, could be sold to steel manufacturers for beds of open-hearth furnaces. Thus do engineers turn liabilities into assets and further the progress of economical conservation.

High praise was heard of other sessions as well; the materials-handling sessions especially were largely attended and favorably commented on.

The session on applied mechanics resulted in the usual enthusiastic discussion. The value of the efforts of this vigorous and important division is becoming more and more evident. It was remarked by Burt L. Newkirk, chairman of the session, however, that few teachers of applied mechanics had attended the meeting, representation being almost entirely from industry. Aside from the fact that instructors have classes to meet which cannot always be put off, the burden of expense involved in attending engineering meetings is, in most cases, too great to be met by members of the teaching profession. Most representatives from industry attend engineering meetings at the expense of their employers, who find in such gatherings many benefits which make the cost to them a profitable investment. Colleges, too, would find this to be true. Some way should be found so that members of the faculties of engineering colleges could be on a par with representatives of industry in benefiting from meetings of engineers. These men need the contacts afforded by such experiences and the inspiration and refreshed viewpoint which come with them just as much as do the others. Ways and means should be provided so that the universities could pay the expenses of deserving and ambitious instructors at meetings of engineering and scientific societies.

To the hosts of the Society at Akron, the visitors who enjoyed the hospitality and the technical events extend most hearty thanks.

Elastic and Inelastic Behavior in Spring Materials

(*Continued from page 916*)

The results (Fig. 1) are given in millionths of an inch per inch length of specimen, and the measurements involved are so minute and so close to the limits of accuracy of the instrument used that too great consistency must not be expected in the lower load ranges.

A study of these elongation readings gave the first definite indication that the true modulus of elasticity of the material changed as the load increased. In the second series of runs, taken after the specimen had been loaded to the yield point, the elongation readings were consistently higher than in the first series; and in the third series, after still greater overload, the readings were still higher.

With this as a clue a program of measurements was planned with the special purpose of studying the true elastic stress-strain curve. The most obvious method was to take measurements over the complete stress-strain curve itself, from zero load to the yield point. This immediately introduced the factor of elastic hysteresis, and also made it impossible to study the elastic elongation of the bar as separated from the effect of minute plastic yield which might be simultaneously occurring. To avoid these effects, the total curve was broken up into a series of short sections, each of short enough range so that the elastic hysteresis within that range would be small.

A study of the figures obtained reveals a relatively steady increase with increasing load in any one series of runs. This, of course, indicates a decreasing modulus of elasticity. From series to series, the variations are within experimental limits of error until after the fifth series. At the end of the fifth series, the load was raised to 10,400 lb., equal to 174,500 lb. per sq. in., and held there for some time. This was sufficient to cause permanent elongation of the order of magnitude of two-tenths of one per cent; and resulted in a slight decrease in the average values of modulus of elasticity. A further overload, to 181,000 lb. per sq. in., equivalent to an elongation of one-half per cent, resulted in a much more perceptible decrease in modulus.

When computing moduli of elasticity, corrections were made for the effect of any temperature variations upon the modulus, and for the effect of changes in area of cross-section of the over-strained material. The effect of the elastic decrease in cross-section upon the apparent value of the modulus was also computed, but for theoretical reasons was disregarded. It is in any event small. At the beginning of each successive short run, the gage length was reset at an actual 8 in., so correcting for both elastic and plastic increase in gage length. If the customary method had been employed, and the gage points left unchanged, the effect would have been to accentuate the decreases in modulus already described.

In closing, reference should again be made to the fact that a large amount of time and attention has been required for each series of tests, and that therefore only a small variety of samples have been tried. The results, as representing a general law, are consequently tentative. On the other hand, the evidence in favor of the curved stress-strain line is increased by the fact that for some time past the theories regarding the nature of atomic attraction and repulsion have called for just such curvature. This aspect of the case can well be taken up at some other time.

Acknowledgment should be made to Union College, for the use of its facilities in this investigation, and to Henry W. Sory, through whose skill and care in experimental operations these sets of readings have been made possible.

John William Lieb

A Pioneer in the Central-Station Industry

DR. JOHN WILLIAM LIEB, Past Vice-President of The American Society of Mechanical Engineers, 1906–1908, Senior Vice-President of the New York Edison Company, and an engineer and executive of international reputation, died at his home at Beechmont, New Rochelle, N. Y., on Friday, November 1, following an illness which had confined him to his bed for about six weeks.

Dr. Lieb was born in Newark, New Jersey, on February 12, 1860. He was the son of John William and Christina Zens Lieb, who had immigrated from Wurtemburg and entered into the life of the thriving New Jersey city. His early education was obtained in the local public schools and the Newark Academy, following which he entered the Stevens High School at Hoboken, New Jersey. After being graduated from this school in 1876 he entered the Stevens Institute of Technology, from which he was graduated in 1880, receiving the degree of Mechanical Engineer.

JOHN WILLIAM LIEB—1860-1929

His mind had early turned toward the new discoveries which at that time were being made public along electrical lines, and shortly after his graduation he entered the employ of the Brush Electric Company in Cleveland, Ohio, where he worked on the arc-light systems as a draftsman. He soon saw that the arc-light system had about reached the limit of its development, and after a few months, in January, 1881, he entered the employ of Thomas A. Edison, of the new Edison Electric Light Company, as draftsman in the Engineering Department, at 65 Fifth Avenue, New York. Here he assisted in making the plans for the "Jumbo" dynamos and in the design of the switches, regulating apparatus, and other electrical equipment for the new Pearl Street Station in New York which was to be the first central station in the world for the general distribution of electrical energy for utilization as light, heat, and power from an underground system of mains. Later in the year he was transferred to Mr. Edison's experimental and testing department at the Edison Machine Works, Goerck Street, New York, where he became engaged in researches and investigations on electric meters, regulators and electrical apparatus, under the personal direction of Mr. Edison. Early in 1882 he was assigned to the construction of the Pearl Street Station, in general charge of the planning and installation of the electrical equipment. When this station was put into regular operation on September 4, 1882, under the auspices of the Edison Electric Illuminating Company of New York, he was given the appointment of electrician in charge of the electrical equipment. It is a curious fact that the term "electrical engineer" apparently had not at that time been invented, and this title of "electrician" was probably the first central-station title pertaining to the electric industry.

These new responsibilities Dr. Lieb filled for only a short period, since in November of the same year he was selected by Mr. Edison to proceed to Milan, Italy, to direct the design and installation of the first Milan Edison Station, in the old Via di Santa Radegonda.

On the organization of the Società Generale Italiana di Elettricità, Sistema Edison, he was appointed its chief electrician, then chief engineer, and finally technical manager and director of stations. The Milan station, which was started in regular service in March, 1883, was for a considerable time the largest and most successful electric light and power station in Europe. Besides the Edison direct-current system, the Milan company was among the first to install, in 1886–1888, an alternating-current system of distribution utilizing, among the very first applications, the connection of transformers in parallel according to the Zipernowsky, Deri, and Blathy patents, exploited by Ganz & Company of Budapest. Here was also done pioneer work in the transmission of high-tension alternating current at 2400 volts, through concentric underground cables, to consumers located several miles from the central station. Under Dr. Lieb's direction, there were also undertaken in Milan some of the first experiments in operating large direct-driven alternators in parallel.

The Thomson-Houston series arc system, with arc-light machines supplying 50 lamps in series, received here one of the earliest applications in Europe, and was extended later throughout the whole city from a separate arc-light station. The earlier arc-light poles had always been offensive to his esthetic sense, and he inaugurated the use of artistically designed poles which were much more pleasing to the eye. In 1893 there was put into regular service, under Dr. Lieb's direction, in Milan, one of the earliest trolley systems in Italy, furnishing regular, from the Piazza del Duomo to outlying districts.

In the meanwhile he had returned to New York to be married to Miss Minnie F. Engler on July 29, 1886, taking her back with him to Milan where he continued his work in popularizing and extending the use of electric light, heat, and power. It was during this visit to America that Mr. Lieb joined The American

Society of Mechanical Engineers. In his connection with the Italian Edison Company, he acted as adviser for many financial and industrial corporations engaged in the electric business where his active and enthusiastic mind, united with the judgment of a manager and executive, assured sound methods in the exploiting and extension of the electric industry. Already the possessor of two languages, German and English, from early life, he had become master of Italian and French, even speaking the local dialects with considerable ease.

DR. LIEB'S PIONEER WORK IN ITALY

For his pioneer work in connection with the introduction of electric-light and power service throughout Italy and the installation of the electric trolley system in Milan, he was decorated by the Italian Government, Knight Commander of the Royal Order of the Crown of Italy, and later promoted to Grand Officer. In 1925 he was made "Ufficiale" of the Order of S. S. Maurizio e Lazzaro, and in 1928 was honored by the French Government, receiving the decoration of Officer of the Legion of Honor.

In 1894, Dr. Lieb returned to America, becoming assistant to R. R. Bowker, then vice-president and executive of the Edison Electric Illuminating Company of New York. The next four years were most fruitful in the development of the use of electric light and power in New York City, and Dr. Lieb made three visits to Europe in connection with other officials of the company preliminary to the design and construction of the Waterside Station and the adoption of high-tension alternating-current generation with rotary converters and low-tension direct-current substations for the Edison system. These years also saw the first storage battery installed on the Edison System. On January 1, 1898, the control of the company passed into the hands of A. N. Brady, with T. E. Murray as vice-president. At this time Dr. Lieb became third vice-president and general manager, serving in this capacity until the company's reorganization as the New York Edison Company in 1901. In the reorganized company he became associate general manager, vice-president, and general manager, and finally senior vice-president, which office he held at his demise. During this period he had general charge of the installation and operation of the power plants and distributing systems in New York, and was the executive in charge of the company's technical operations, with supervision over all technical research and developmental work.

Dr. Lieb was senior vice-president and a director of the New York Edison Company; president and chairman of the board of The Electrical Testing Laboratories; vice-president and member of the board of directors of the Yonkers Electric Light and Power Company; member of the board of directors of the United Electric Light and Power Company, and of the New York and Queens Electric Light and Power Company; vice-president of the Edison Electric Light and Power Installation Company; director and member of executive committee of the International Power Securities Corporation; and director of the Brush Electric Illuminating Company, the Empire City Subway Company, and the Consolidated Telegraph and Electrical Subway Company.

DR. LIEB'S MANY SOCIETY CONNECTIONS

Dr. Lieb was a past-president and fellow of the American Institute of Electrical Engineers; past-president of the Association of Edison Illuminating Companies, National Electric Light Association, the New York Electrical Society, and the Edison Pioneers; past vice-president of The American Society of Mechanical Engineers; fellow of the New York Academy of Sciences; trustee of the Stevens Institute of Technology; trustee and vice-president of the The Museums of the Peaceful Arts; trustee of the Italy-America Society; and member of the American Society of Civil Engineers, Illuminating Engineering Society, Franklin Institute of Philadelphia, American Association for the Advancement of Science, and of numerous other professional and civic organizations, national and local. He was an honorary member of the Society of Italian Engineers and Architects, and of the Society of Italian Railway Engineers; vice-president of the Union Internationale des Producteurs et Distributeurs d'Energie Electrique; and a member of the Elektrotechnischer Verein, the Associazione Elettrotecnica Italiana, the Institution of Electrical Engineers of Great Britain, the Royal Society of Arts, and the Newcomen Society of London.

He was for many years past the chairman of the Lamp Committee of the Association of Edison Illuminating Companies, and during the war was chairman of the National Committee on Gas and Electric Service, representing in Washington the public-utility companies (gas, electric, and street-railway service) of the country in their cooperative relations with the various departments of the Government. He was a member of the Committee on Public Utilities of the U. S. Chamber of Commerce, on which he represented the National Electric Light Association as its National Councilor; chairman of the N.E.L.A. delegation to the International Chamber of Commerce; representative of the N.E.L.A. on the International Association of Producers and Distributors of Electrical Energy; member of the New York Chamber of Commerce and of its Committee on Internal Trade and Improvements; member of The Merchants Association of New York and chairman of its Industrial Committee; member of the National Industrial Conference Board and Chairman of the Joint Fuel Committee representing the National Public Utility Associations; member of the Committee to study plans for cooperation between War Departments and the National Association of Manufacturers; and a member of the Committee on Standardization Survey, the American Society of Military Engineers, and the National Research Council.

He served in international matters as: Chairman, Section E, International Electrical Congress, St. Louis, 1904; representative, U. S. Department of State at International Railroad Congress, Rome, 1922; member, U. S. Executive Committee, World Power Conference, London, 1924; U. S. delegate, International Congress on Illumination, Geneva, 1924; chairman Reception Committee, International Electrotechnical Commission Meeting, New York, 1926; vice-president, International Association of Producers and Distributors of Electrical Energy, Paris, 1928; and executive chairman, American Organization Committee, World Engineering Congress, Tokyo, Japan, 1929.

Dr. Lieb had always been most sympathetic with the youthful aspirant to a position in the engineering profession. He valued highly the training he had received at the Stevens Institute of Technology and maintained a very active interest in engineering education and the progress of his Alma Mater. He served as president of the Alumni Association in 1896–97, and as alumni representative on the Board of Trustees of Stevens Institute from 1908 to 1911. In 1921 he received from his Alma Mater the honorary degree of Doctor of Engineering, and in 1927 became a life member of the Board of Trustees.

He was equally interested in society affairs, becoming a member of the The American Society of Mechanical Engineers in 1886, the American Institute of Electrical Engineers in 1887, and the American Society of Civil Engineers in 1898. He was elected manager of the American Institute of Electrical Engineers for the terms 1896–1899 and 1901–1903, vice-president from 1899–1901 and from 1903–1904, and served as president of the Institute in 1904–1905. In 1913 he became a fellow of the same society. He was elected manager of The American Society of Mechanical Engineers for the term 1903–1906, and vice-president for the term 1906–1908. He was greatly interested in the affairs

of the United Engineering Society, and particularly of its library, serving continuously on its library committee from 1909 to 1917. Outside these activities he gave freely his time and advice in the furtherance of the work of these technical societies.

Very early in his career, Dr. Lieb acquired a facility in reading which placed him in a most advantageous position. The ability to read a book which normally would require five or six hours in a mere fraction of that time, was undoubtedly helped by the quickness of his cognitions and his logical and orderly process of thought. His interests widened with every avenue which his reading opened before him. Besides the sciences, the arts, the humanities, and the technical branches allied to his own profession became part of his mental make-up. During his residence in Italy he became a deep student of history and its allied science of archaeology. He became interested in the work of that "universal genius" Leonardo da Vinci, and for many years was engaged in the critical study of his notebooks, investigating and translating sketches and texts covering Leonardo's work, particularly in the fields of natural science and engineering. He became a member of the "Raccolta Vinciana" of Milan, and in the course of years collected what is probably the largest collection of Vinciana in existence.

Dr. Lieb delivered many lectures on engineering, industrial, and economic subjects in many of the leading universities and technical schools in the United States, and contributed many reports, papers, and discussions to the transactions of professional and learned societies. On February 4, 1924, he was awarded the Edison Medal by the American Institute of Electrical Engineers for his work in connection with the development and operation of electric central stations for illumination and power.

Light's Golden Jubilee, which was recently celebrated, received its first formal suggestion on Edison's 82nd birthday, February 11, 1929, when at a luncheon of the Edison Pioneers—that gallant body of men who were associated with the great inventor in his pioneering days—their fellow-member, Dr. Lieb, tentatively outlined the celebration and the Pioneers approved a resolution authorizing the appointment of a committee to propose to the electrical industry the sponsoring of the celebration.

With the vision of the pioneer, the well-considered knowledge and training of the scientist, and the wide sympathies of the humanitarian, he endeared himself to every one with whom he came in contact. Many people of diverse races, training, and sympathies have said of him, "he talks to us in our own language," and he had the faculty of picking out, as it were, the underlying idea, the main trend, the crux of a situation, and of divesting it of all extraneous matter, going straight to the root of things. His reasoning was never oblique but logical and cogent, sparing none, not even himself, in the strength of his analysis of a situation.

His sympathies were wide, ranging over the entire realm of human activities; his versatility and general knowledge might be termed encyclopedic, to which many specialists in various lines have testified. His English vocabulary was perhaps his most wonderful achievement, and his writings have always been models of clearness and good expression, using the right word in the right place to obtain just the shade of meaning he desired. His wide sympathies were well known, and his office was opened to everybody, while his philanthropic work usually made more demands on his strength than he could well afford.

Dr. Lieb is survived by his wife, who prior to their marriage in 1886 was Miss Minnie F. Engler, two daughters, Misses Minnie E. and Julia C. Lieb, and a son, Adolph W. Lieb. A brother, Oscar J. Lieb, and two sisters, Mrs. Charles Oscar Baldwin and Miss Anna Lieb, also survive.—G. A. O.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Public Utilities and Higher Education

PUBLIC UTILITIES: A Survey of the Cooperative Relations Existing Between the Public Utilities and Higher Education in the United States of America. Published by the National Electric Light Association, 1929.

IN 1923 the National Electric Light Association appointed a committee to cooperate with the higher institutions of learning. This committee became interested in the survey here considered when the results of the Yale University study of transportation appeared in 1926 under the title "Transportation—A Survey of Current Methods of Study and Instruction and of Research and Experimentation."

In June, 1927, the National Electric Light Association employed a Director of Survey who, with the counsel and the assistance of fifteen university men, planned and carried out a survey on public utilities similar to the Yale University Survey on transportation. The entire committee, as constituted for this Survey in October, 1927, consisted of sixteen university men and thirteen members from industry, but the report of the Survey was prepared only by the educational members of the committee without participation of the representatives from the utility industry.

This survey endeavored to secure data concerning the extent of instruction in the field of public utilities in colleges and universities, the character and extent of the demand of the public-utility industry for college graduates, the character of the opportunities for college graduates in this industry, and the willingness and ability of industry to cooperate with colleges and universities.

The findings of this Survey may be summarized as follows:

1 A very large majority of the utility companies are highly satisfied with the college men in their employ, and state that the

opportunities are sufficiently attractive to warrant college men to prepare themselves for a life work in the public-utility industry.

2 An increasing number of graduates of both schools of engineering and schools of business are entering the public-utility field. Of all employees, 13.5 per cent are engineering graduates and 12.3 per cent are non-engineering college graduates, but the greatest number of men employed in 1927 were non-engineering graduates.

3 Replies to questionnaires sent to the public-utility industry are somewhat inconsistent when dealing with educational problems. The public utilities state that they are interested in a broad type of education, but in their suggestions for the improvement of the college graduates they stress more field work, cooperative courses with industry, more practical problems in university instruction, and more specialized courses in public utilities.

The main criticism of engineering graduates is that they need more instruction in business. It is a question, however, as to whether the engineering graduates will be more successful if courses in business are substituted for the scientific and technological subjects now included in the engineering curricula. Furthermore, what are courses in business?

4 Aside from the telephone industry, the public utilities have much room for improvement in their methods of recruiting college graduates.

5 The methods now used for employee education seem to be inadequate both for college and non-college men. Public utilities have a definite opportunity if not an obligation in providing field experience for undergraduates during vacations and in offering more adequate programs of employee education for college graduates who enter industry. Only about half of the companies provide summer or other temporary employment for college men. There appears to be a conviction that college education could be effectively coordinated with employee educational courses.

6 There seems to be a need for more effective coordination of the fields of business and of engineering education in the training of men for the public-utility industry. Students in engineering colleges should be provided with instruction in business and economics which is much less specialized than that ordinarily given to students in schools of business. Engineering colleges are willing to develop to some extent instruction which will enable students in the schools of business to gain technical knowledge which will be helpful to them in appreciating the engineering problems of public-service corporations.

7 Replies from 22 engineering colleges indicate that in 1927 the public utilities, other than railroads, attracted 17.5 per cent of the graduates; the railroads employed only 3.8 per cent. On the other hand, courses in economics offered in colleges give more attention to railroads than to public utilities other than railroads.

8 Only about one-fourth of the companies report any cooperation with colleges and universities. Colleges feel that the public-utility industry can be helpful to higher education by supplying statistical and technical information, by donating funds for the establishment of special chairs under the control of educational institutions, by supplying special lecturers, and by employing students and even teachers in the industry during vacations.

The report suggests the employment of representatives of the public-utility industry to cooperate with educational institutions in problems pertaining to the employment of their graduates and to act as a clearing house to help faculty members in their studies of public-utility problems.

Short courses during the summer and at other times of the year are advocated for those employed in the public-utility industry. A number of engineering colleges are now offering such courses.

The report recommends that the utilities other than railroads should consider the establishment of a centralized bureau, similar to the Bureau of Railway Economics, for the collection and dissemination of statistical, factual, and other objective data.

The report of this Survey indicates that the public utilities are interested in cooperating with colleges and universities, and effective steps for such cooperation are clearly brought out.

Books Received in the Library

ALUMINIUM-KOKILLENGUSS. By H. Obermüller. V.D.I. Verlag, Berlin, 1929. Paper, 6 × 8 in., 84 pp., illus., diagrams, tables, 4 r.m.

A concise handbook on permanent-mold casting and die casting. The alloys used, the construction of molds, casting processes, methods of testing, and the equipment of plants are discussed from a practical point of view.

ANALYSE DILATOMÉTRIQUE DES MATÉRIAUX. By Pierre Chevenard. Dunod, Paris, 1929. Paper, 9 × 11 in., 79 pp., illus., diagrams, 25.50 fr.

Professor Chevenard discusses the value of the dilatometric method in the study of thermal changes in metals, describes the apparatus and methods that he has evolved at the Imphy steelworks, and gives some of the interesting results that he has obtained in studying the quenching of aluminum bronze, the graphitization of cast-iron, the firing of refractories, and other industrial processes.

DIE DAUERPRÜFUNG DER WERKSTOFFE. By O. Föppl, E. Becker, and G. v. Heydekampf. Julius Springer, Berlin, 1929. Paper 7 × 10 in., 124 pp., illus., diagrams, 9.50 r.m.

A discussion of apparatus and methods for determining the fatigue of metals subjected to vibration. A variety of testing machines is described, their use explained, and methods of testing given, together with some results.

DÉFORMATIONS PERMANENTES ET RUPTURES DES ACIERS. By Paul Régnauld. Dunod, Paris, 1929. Paper, 7 × 10 in., 90 pp., diagrams, tables, 23.30 fr.

Brings together the work of various investigators upon the effect of permanent deformations and sudden shocks on the strength of steel. The formation of permanent deformations and the ruptures that these may cause, the effect of shock, and the stability of equilibrium of deformed steel are discussed.

LA FABRICATION DE LA FONTE MALLÉABLE. By Camille Busquet. Dunod, Paris, 1929. Paper, 7 × 10 in., 157 pp., illus., diagrams, tables, 35.50 fr.

A general account of the physical and chemical properties of malleable cast iron, of the principal methods of manufacture, and of the important characteristics of malleable castings. The book appears to be intended for the inspector or buyer of castings rather than for the metallurgist, and treats the subject from the point of view of the former.

DIE GESTALTUNG UND BERECHNUNG VON RAUCHGASVORWÄRMERN. By Lothar Possner. Julius Springer, Berlin, 1929. Paper 7 × 10 in., 152 pp., illus., diagrams, tables, 14.50 r.m.

A thorough discussion of economizer design, which explains in detail the necessary calculations and their underlying principles, and also shows various existing designs. Numerous tables and formulas for the designer are included.

HOCHWERTIGER GRAUGUSS. By Eugen Piwowarsky. Julius Springer, Berlin, 1929. Bound, 7 × 10 in., 336 pp., illus., diagrams, tables, 42 r.m.

This monograph is a summary of the results of modern work which has been directed to the improvement of cast iron. The

book sets forth the principles of physical metallurgy and discusses such topics as the speed of graphitization and the influence upon it of other elements, the effect of casting temperature, the influence of other elements upon its mechanical properties, the effect of heat treatment, the melting of pig iron, processes for improving castings, etc. A valuable summary of the existing information upon cast iron is achieved.

DAS HOLZ; general presentation of the production, manufacture and application of Cumbee, published by *Vereines deutscher Ingenieure*, jointly with the German Forestry Association, in Gemeinschaft mit dem Deutschen, by J. A. v. Monroy. V.D.I. Verlag, Berlin, 1929. Cloth, 7 × 10 in., 318 pp., illus., diagrams, 19.50 r.m.

A general survey of the wood industry, prepared by the Society of German Engineers and the German Forestry Society. Methods of forestry and lumbering are described briefly, followed by descriptions of methods of testing, protection against decay, steaming, drying, bending, and dyeing. Two-thirds of the volume is given to the uses of wood in various kinds of construction, in veneers, as a chemical raw material, and as fuel. The book includes much material usually widely scattered.

HUMAN NATURE AND MANAGEMENT, the Applications of Psychology to Executive Leadership. By Ordway Tead. First edition. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 312 pp., $3.50.

Aims to give an understanding of psychology and to show how to apply its findings in managerial work. The book presents the outlines of psychology, with emphasis on those aspects of behavior which are directly related to executive problems, and explains the applications of psychological knowledge to specific tasks.

HYDRAULIC LABORATORY PRACTICE; translated; revised to 1929, of Die Wasserbaulaboratorien Europas, by V.D.I. Edited by John R. Freeman. The American Society of Mechanical Engineers, 1929. Cloth, 9 × 12 in., 868 pp., illus., $10.

Some years ago Dr. John R. Freeman urged the Society of German Engineers to publish a volume describing the hydraulic laboratories of Europe and the principal research work of each of them. The result of this suggestion was "Die Wasserbaulaboratorien Europas," which appeared in 1926, and which now appears in English under Dr. Freeman's editorship.

The English edition will be of interest to every hydraulic engineer. To the professor of hydraulics it affords descriptions of the important laboratories of the world, of their equipment, organization, management, and of the work which they have carried out. The engineer in practice will find many helpful data in the text and in the numerous bibliographies. No such general survey of experimental activities in this science has hitherto existed.

The translation contains much more material than the original. Appendixes describing other European laboratories, and some American ones, have been added. Biographies of the directors of the various laboratories have been inserted, as well as several monographs on important general subjects.

INCLUSIONS IN IRON. By C. R. Wohrman, Cleveland. American Society for Steel Treating, 1928. Cloth, 6 × 9 in., 162 pp., illus., tables, $3.

This research is essentially a photomicrographic study of the inclusions created in iron by oxygen, sulfur, and manganese, undertaken as a contribution upon the problem of how to govern these inclusions. The author first describes in detail the methods used in making artificial known inclusions and in preparing and examining the specimens. He then gives an account of the results obtained, and presents the conclusions reached.

INDUSTRIAL ECONOMICS. By Dexter S. Kimball. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 312 pp., illus., diagrams, charts, $3.

The author endeavors to set forth some of the new ideas that have come into use in production and administration during the last twenty-five years, and to indicate the growing use of well-known economic principles in solving the difficult problems in those fields which arise as enterprises grow in size and complexity. His presentation of the economic background of the manufacturing industry is based on his courses at Cornell University.

INDUSTRIALS, THEIR SECURITIES AND ORGANIZATION. By Sterling H. Bunnel. Shaw, Chicago, 1929. Cloth, 6 × 10 in., 334 pp., illus., diagrams, $5.

The author's purpose is to point out that the earning power and investment value of industrial concerns depend not only upon the value of its tangible assets, but also upon many intangibles, such as the product, the efficiency of its marketing, the relations with its workers, the location of its plant, and the quality of its management. These intangibles are discussed and their importance pointed out, with advice upon the investigation of proposed investments.

INTERNAL-COMBUSTION ENGINES, THEORY AND DESIGN. By Robert L. Streeter and Lester Clyde Lichty. Third edition. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 445 pp., illus., tables, diagrams, $4.

The third edition differs markedly from the second. Much descriptive matter has been eliminated, and the space used to present the underlying principles of internal-combustion engines as understood today. Chapters on lubrication, valves, engine balance, and vibration have been added, and many old chapters rewritten. Special attention is given to liquid-fuel engines of the automotive type.

INTERNATIONAL AIRPORTS. By Stedman S. Hanks. Ronald Press Co., New York, 1929. (Ronald Aeronautic series.) Cloth, 6 × 9 in., 195 pp., illus., $5.

In 1928 the author visited the principal European airports to ascertain what lessons could be learned that would be useful in constructing and managing airports in America. He collected much information upon the layout of these ports, the buildings, the methods of handling traffic, and the other details of air travel, which is presented and compared with American practice.

DAS IT—DIAGRAMM DER VERBRENNUNG. By P. Rosin & R. Fehling. V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 32 pp., 10 charts.

Starting with a hitherto unknown relation between the heating value of a fuel and the volume of gas evolved, the author has prepared charts from which the heat capacity of the flue gas can be read off. With these diagrams, it is only necessary to know the heating value of a fuel and the excess of air used to obtain the temperature of combustion, the available heat drop, the thermal efficiency, and similar data. The pamphlet explains the theory, illustrates the practical use of the method and gives diagrams for solid, liquid, and gaseous fuels.

JAHRBUCH 1929 DER DEUTSCHEN VERSUCHSANSTALT FÜR LUFTFAHRT, E. V., Berlin-Adlershof. Edited by Wilhelm Hoff. R. Oldenbourg, Munich and Berlin, 1929. Cloth, 9 × 12 in., 480 pp., illus., diagrams, tables, 42 r.m.

The report contains an account of the activities of the laboratory, including a list of all reports prepared during the year, whether issued or not: and reports Nos. 101–140, most of which have already appeared in "Luftfahrtforschung." These reports cover a wide range of important problems connected with avia-

tion, airplane construction, and materials, and give the results of much valuable experimental work.

Das Künstliche Holztrocknen (Deutsche Bearbeitung des Werkes "The Kiln Drying of Lumber," by A. Koehler and R. Thelen). By P. Warlimont. V.D.I. Verlag, Berlin, 1929. Cloth, 6 × 9 in., 142 pp., illus., diagrams, 12 r.m.

A translation, with some additions, of the American book, "The Kiln Drying of Lumber."

Massenermittlung, Massenverteilung und Kosten der Erdarbeiten. By Wilhelm Müller. Ernst, Berlin, 1929. Paper, 7 × 9 in., 94 pp., illus., tables, diagrams, 7.50 r.m.

Methods of calculating earthwork, haul and mass calculations, cost computing, etc., are discussed. The author presents original methods of computation which are claimed to be more exact and quicker than those used heretofore.

Motor Vehicles and Tractors. By P. M. Heldt. P. M. Heldt, Nyack, N. Y., 1929. Cloth, 6 × 9 in., 678 pp., illus., diagrams, tables, $8.

A textbook on design, covering all the elements of the automobile and tractor except the engine and electrical equipment. The book is intended to replace the former second volume of the author's "Gasoline Automobile," and repeats some of that material, but is principally a new work. The book is suited for class or home study, uses only simple mathematics, and contains much practical information.

Pipe and Tube Bending and Jointing. By Stanley P. Marks. Pitman, New York, 1929. Cloth, 5 × 8 in., 159 pp., illus., tables, diagrams, $1.75.

A practical instruction book, giving definite instruction on methods of bending and connecting pipes of the ordinary metals. Intended for plumbers, electricians, and pipe-fitters generally.

Les Pompes Centrifuges. By C. Pfleiderer. Translated and annotated by Louis Bergeron. Dunod, Paris, 1929. Paper, 7 × 10 in., 508 pp., illus., diagrams, 118.70 fr.

Professor Pfleiderer's "Die Kreiselpumpen," which has taken rank as one of the most important treatises on centrifugal pumps, here appears in a French translation. The translator has added to the value of the book by numerous notes giving his own ideas and the results of his own investigations and experience.

Principles of Metallurgy. By John L. Bray. Ginn & Co., Boston, 1929. (Engineering series.) Cloth, 6 × 9 in., 568 pp., illus., tables, $5.80.

A concise presentation of metallurgical practice from the mining of the ore to the sale of the refined metal. Refractories, fuels, and metallography are also treated, and references to further information given. Should be especially useful for students of other branches of engineering who wish a general survey of this subject.

Principles of the Heat Treatment of Steel. By the Metallurgical Staff of the Bureau of Standards. American Society for Steel Treating, Cleveland, 1928. Cloth, 6 × 9 in., 93 pp., $1.50.

Presents the elementary facts and principles in concise form and in the simplest terms possible. The book is intended as an introduction to more extensive treatises and periodicals for use by beginners and practical men. A valuable bibliography is included. The book is confined to carbon steels.

Railway Engineering and Maintenance Cyclopedia. Third edition edited by Elmer T. Howson. Simmons-Boardman Publishing Co., New York, 1929. Cloth, 9 × 12 in., 1116 pp., illus., plates, diagrams, $7.

This well-known manual of American railroad practice covers the construction and maintenance of the fixed property. Track, bridges, buildings, water service, and signaling are covered, attention being given to the materials used, the processes of construction and operation, and the equipment employed. Correct definitions of terms are given, and the latest standard specifications.

Renforcement des Soudures, Couvre-Joints Discontinus Soudes. By E. Hoehn. Ch. Béranger, Paris et Liège, 1929. Paper, 6 × 9 in., 103 pp., diagrams, tables, 20 fr.

A study of the value of welded butt straps as a reinforcement of welded joints in boilers and other pressure vessels. The results of tests are given and the distribution of stresses discussed. Data are given for use by designers.

Steam and Gas Engineering. By Thomas E. Butterfield. D. Van Nostrand Co., New York, 1929. Cloth, 6 × 9 in., 481 pp., illus., diagrams, tables, $4.50.

An introductory text for engineers by the professor of heat power engineering at Lehigh University. The entire field of power production from steam and gas is covered, with emphasis upon the natural laws involved and upon the various kinds of apparatus used to apply them in practice. Several chapters are devoted to descriptions of engines, boilers, gas producers, and other apparatus. Many problems are given.

Theorie und Technik der Flugaschenabscheidung mit besonderer Berücksichtigung der Kohlenstaubanlagen im Europäischen Auslande. By E. Heitmann. (Berichtfolge des (Kohlenstaubausschusses des Reichskohlenrates. No. 2.) V.D.I. Verlag, Berlin. Paper, 8 × 12 in., 45 pp., illus., diagrams, 3 r.m.

The author was commissioned in 1928 to visit the countries in western Europe and study the methods in use for meeting the smoke problem, especially in plants burning pulverized coal. His report discusses the theory of ash separation from flue gases and methods of measuring the separation attained, and describes and criticizes the noteworthy systems of ash elimination in use. Some remarks are made on possible uses for fine ash and on the expense of collection.

Transactions of the Fuel Conference. World Power Conference, London, 1928. Percy Lund, Humphries & Co., 1928. Fabrikoid, 6 × 10 in., 4 vol., illus., diagrams, maps, tables, fabrikoid, £12.

A wealth of information on the preparation, transmission, and utilization of fuel is here made available. Nearly 170 papers, prepared by authorities from 48 nations, present the best practices in these subjects and suggest improvements.

Volume one is devoted to the coal and oil industries. The economic and general considerations of these industries, the sampling and testing of coal, its cleaning, drying, and briquetting, and the composition, classification, preparation, storage, and handling of liquid fuels are discussed.

Volume two considers the composition, preparation, storage, and handling of gaseous fuels and the products of the carbonization industry, the utilization of fuels for generating steam and producing electricity, and the utilization of fuels and electricity for industrial-furnace work.

Volume three covers various topics: the domestic utilization of fuels and electricity, low-temperature carbonization, pulverized fuel, internal-combustion engines, power transmission, waste-heat recovery, peat, and power alcohol. An elaborate general index forms the fourth volume.

The papers emphasize the economic aspects of these subjects rather than the technical. Together, they form the most exhaustive report on fuel in existence.

THE ENGINEERING INDEX

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Mechanical Engineering Section

THE ENGINEERING INDEX furnishes a Weekly Card Index Service of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Items of particular interest to mechanical engineers are selected for presentation each month in this Mechanical Engineering Section. In operating The Engineering Index, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession.

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AIRPLANE ENGINES

Barrel. A New Barrel Engine. Aeroplane (Lond.), vol. 37, no. 9, Aug. 28, 1929 (Aeronautical Engineering Supplement), pp. 561–562 and 564, 3 figs. Possibilities in wobble-plate or barrel-type, of engine for airplane are discussed; explanation of how Turner Model X engine converts reciprocating motion of piston into rotary motion of shaft and, at same time, effects speed reduction between cycle of operation of piston and final revolution of shaft; ratio may be 1 to 1, or if desirable, any ratio up to infinity; efficiency and durability of design; saving in first cost.

Humidity Effects. Horsepower Correction for Atmospheric Humidity, D. B. Brooks. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 277–283, 8 figs. Results of series of tests made on two multi-cylinder engines to determine effect of humidity on engine performance; basis was oxygen-content hypothesis that presence of any given volume of water vapor in cylinder, by lessening oxygen present, reduces quantity of fuel that can be burned efficiently per cycle decreasing power output; nomograms enabling humidity correction to be obtained from thermometer and barometer readings given.

Spark Plugs. The Development of Sparking Plugs for Aircraft Engines. Aeroplane (Lond.), vol. 37, no. 9, Aug. 28, 1929 (Aeronautical Engineering Supplement), p. 565, 4 figs. Design of Lodge Aero A-40, A-30, and A-20 spark plugs is discussed; early design of mica-insulated spark plug; used for high-compression engines, Model A-30 has patented heat-conducting copper sleeve between mica and steel-alloy center pin; making plug for Rolls Royce F type engine that will withstand great heat; A-20 used for engines of medium compression.

Pistons. Heat Flow in Aircraft Engine Pistons, C. F. Taylor and M. S. Huckle. Aviation, vol. 27, no. 12, Sept. 21, 1929 (Aeronautical Eng. Supp.), pp. 634–639, 10 figs. Results of investigation to determine amount of heat leaving piston by convection to air and vapor in crankcase; apparatus used by Huebotter and Young was modified; crankcase gas cooling simulated; increase, due to air flow, in total amount of heat flowing through aluminum alloy pistons was from 23 to 53 per cent of original amount, depending on rate of air flow; increase was appreciably greater in case of ribbed piston. Bibliography.

AIRPLANE MATERIALS

Magnesium Alloys. Magnesium and Its Alloys in Aircraft, W. G. Harvey. Am. Electrochem. Soc.—Advance Paper, no. 34, for mtg. Sept. 19–21, 1929, pp. 367–377, 6 figs. Magnesium metal is one-third lighter than aluminum, and is used in airplane construction; due to its inherent chemical and mechanical characteristics, it has been difficult to work metal into useful shapes; however, recently, through discovery of methods of purification of metal and of methods of heat treatment of magnesium alloys, most fabricating obstacles have been overcome; mechanical properties of magnesium alloys are tabulated.

AIRPLANE PROPELLERS

Fuselage Interference. Airscrew Body Interference. C. N. H. Lock. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 224, Aug. 1929, pp. 631–658 and (discussion) 659–666, 23 figs. Semi-empirical method of using propeller strip theory to take account of mutual interference of body and tractor propeller; brief account of wind-tunnel experiments starting from original tests of family of propellers providing evidence for theory's accuracy; blunt spinner has slight superiority when propeller is far back; best position for housing propeller in nose; effect of body on torque coefficient of any propeller; best relative size of propeller and body; effect of excrescenses. Bibliography.

AIRPLANES

Airfoils. The Prediction of Airfoil Characteristics, G. J. Higgins. Nat. Advisory Committee for Aeronautics—Report no. 312, 13 pp., 17 figs. Methods by which aerodynamic characteristics of air foil may be calculated with sufficient accuracy for use in airplane design are described and developed; these methods for prediction are based on present aerodynamic theory and on empirical formulas derived from data obtained in N.A.C.A. variable-density wind tunnel at Reynolds' Number corresponding approximately to full scale. Bibliography.

Autogiros. See AUTOGIROS.

Design. Possible Improvement of Present-Day Aircraft, H. Alfaro. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 207–216 and (discussion) 216 and 224, 6 figs. Devices to increase safety, efficiency, and comfort in flight described with results of wind tunnel research; variable-lift unit improvements; lift-increasing mechanisms with particular reference to flap developed by author; improved rolling control arrangement; locating rail surfaces out of propeller slipstream to increase longitudinal stability; reducing parasite resistance; better utilization of available engine horsepower by employing variable-pitch propeller; protection against fire.

Rubber Tires for. Some Information About Airplane Tires, C. J. Cleary. U. S. Air Services, vol. 14, no. 9, Sept. 1929, pp. 54–58, 4 figs. Airplane tires and automobile tires have little in common; no essential difference in materials but construction differs; functions of automobile and airplane tires compared; mathematical relationship between area of foot print made by tire, inflation pressure, and load carried by tire; airplane tires as shock absorbers; specification data; principle of oversizing of tires, which is carried further in airplane practice rather than automobile.

Seaplanes. See SEAPLANES.

Stability. Airplane Stability, L. B. Richardson. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 225–231 and (discussion) 231–232, 12 figs. Statical and dynamical longitudinal stabilities, lateral and directional stability, autorotation and spinning of airplanes are discussed with special consideration to flat spin; to avoid flat-spinning tendencies, biplanes should be given ample stagger and gap; factors tending to damp yaw should be emphasized without making airplane clumsy from excessive directional stability; weights in fuselage should be concentrated along small portion of length of airplane, and those in tail avoided.

Welding Parts. The Welding of Stamped and Formed Aircraft Parts, S. C. Clark and W. L. Gastob. Metal Stampings, vol. 2, no. 9, Sept. 1929, pp. 709–712, 5 figs. Trends in use of welded-steel construction; design of joints, tests, inspection, and researches.

AIRPORTS

Planning. How Shall We Design Our Airports? W. E. Arthur. Sci. American, vol. 141, no. 4, Oct. 1929, pp. 298–301, 5 figs. Factors to be considered in planning an airport for future traffic; preliminary survey suggested; landing fields no longer suffice; complete airports with every possible facility must be desigued and built; advantages in numerous types of runway surfaces including brick, turf, rolled cinders, and Tarvia; types of hangar roof con-

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

struction and doors; grouping of buildings; subway and overhead bridge idea of passenger concourses.

AIRSHIPS

R.101. R.101, V. C. Richmond. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 33, no. 224, Aug. 1929, pp. 686–715 and (discussion) 715–723, 21 figs. Principal features of British airship R101 and reasons for their employment are discussed; aerodynamic characteristics; transverse and longitudinal structural arrangement; ring frames without radial bracing; shape for bow; fin structure; passenger accommodation; structural detail; pressure control; gas valves; air vents in outer cover.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bronze. See BRONZE.

Magnesium. See AIRPLANES, Materials.

Special. Alloys (Legierungen), E. R. Thews. Giesserei-Zeit. (Berlin), vol. 26, no. 16, Aug. 15, 1929, pp. 450–455. First article of series giving review of special alloys compiled by author and arranged alphabetically; list includes over 3000 alloys which are described briefly; first instalment lists "A" aluminum alloy, aalener zinc alloy, Admiralty bronze, admos metal; adnic; advance metal; aerial; aero metal; aerolite; aeron; aich metal; aix leaf gold; ajax metals; aladar, alargan, albata, and albatra metal, etc.

ALUMINUM ALLOYS

Properties. Aluminium and Its Alloys, A. G. C. Gwyer. Engineer (Lond.), vol. 148, no. 3844, Sept. 13, 1929, pp. 281–283, 8 figs. Review of investigations carried out in recent years on aluminum alloys; advances made in knowledge of corrosion and protection; consideration of constitution of more important aluminum alloys particularly aluminium-copper, aluminium copper-zinc, and aluminium silicon.

ALUMINUM CASTINGS

X-Ray Analysis. X-Ray Inspection of Castings. Elec. World, vol. 94, no. 11, Sept. 14, 1929, p. 530, 2 figs. Figures showing acceptable condition of homogeneity and pronounced flaws justifying rejection.

AUTOGIROS

Principles of. The Autogiro, J. de la Cierva. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 204–206, 1 fig. Principles of autogiro are discussed; present machines also have two small low monoplane fixed wings that act mainly as supports for ailerons, fixed tail, elevator, fin and rudder; efficiency of autogiro and airplane compared.

AUTOMOBILE ENGINES

Carburetors. Stromberg Downdraft Carburetor Obviates Lifting of Fuel, M. W. Baker. Automotive Industries, vol. 61, no. 11, Sept. 14, 1929, pp. 381–382, 2 figs. Description of new features introduced by Stromberg Motor Devices Co. in new Model D series carburetor, which made its first appearance on 1930 Chrysler cars; several changes in jet position and other details were made necessary by reversal of air stream, but general plan of vertical unit was retained; new vacuum accelerating pump; operation of assembly is outlined.

Combustion Chambers. Combustion-Chamber Design in Theory and Practice, W. A. Whatmough. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 249–263, 24 figs. Failure of heat theory; working principles of combustion; reasons underlying decision to use particular type of engine in automobile; limitations imposed upon induction as well as combustion following selection of particular form of combustion chamber; influence of spark-plug location on detonation and pressure rise; overcooling and flame quenching; Whatmough principles of combustion control; super-efficiency combustion chamber head.

Crankshafts—Torque. Inertia Torque. Automobile Engr. (Lond.), vol. 19, no. 258, Sept. 1929, pp. 344–346, 8 figs. Question of torque due to inertia of reciprocating parts of automobile crankshafts is discussed; curves showing relative forces acting on shafts of various types of engines are illustrated; nature of crankshaft distortion caused is considered; best crankshaft arrangement for four- and six-cylinder engines; straight eights built with several different arrangements of crankshaft, one arrangement giving much smaller torque; 8-cylinder diagonal 60- and 90-deg. engines; 12-cylinder engines; radial engines.

Pistons, Machining. Finishing Pistons. Automobile Engr. (Lond.), vol. 19, no. 258, Sept. 1929, pp. 347–348, 2 figs. Methods of finishing automobile-engine pistons are discussed with details of special honing tool developed by Clement Talbot for producing satin finish on cast-iron skirt of their special built up pistons; piston skirt is finished after assembly of gudgeon pin and connecting rod; coned sleeve made with two separate internally coned facings; method is purely finishing process but is carried out on production basis.

AUTOMOBILE PLANTS

Materials Handling. Monorails—the Carryalls in the Studebaker Plant. Am. Mach., vol. 71, no. 13, Sept. 26, 1929, pp. 540–542, 8 figs. Ways in which automobile parts are transported in Studebaker plant with great saving of space are illustrated in eight halftones each accompanied by brief explanation.

AUTOMOBILES

Brakes. Bosch Brake Auxiliary (Der Bosch-Bremshlf), F. Trautmann. Automobil-Rundschau (Berlin), vol. 31, no. 17, Sept. 1, 1929, pp. 359–362, 5 figs. New brake is claimed to be cheap yet reliable and effective; its design and operation are described in detail; important feature is control of braking pressure by electromagnetic valve.

Front-Wheel Drive. Transmission and Worm Gear of Ruxton Front-Wheel Drive Car Are Combined in Single Unit, P. M. Heldt. Automotive Industries, vol. 61, no. 9, Aug. 31, 1929, pp. 298–301, 5 figs. Description of Ruxton front-drive car relating chiefly to transmission and drive features; 8-cylinder in-line Continental engine set on frame with flywheel bell housing forward; arrangement of engine accessories differs considerably from that in other cars; all universal joints used are of Weiss constant-velocity type, one at knuckle end permitting angularity of more than 32 deg.; transmission and final drive combined in single unit.

Riding Qualities. Preliminary Report on Fatigue Produced by Automobile Riding, F. A. Moss. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 298–303, 10 figs. Report of results obtained in study of fatigue incident to motor travel, which is part of Society's Riding Qualities Research program; series of physiological tests conducted after muscular fatigue had been induced by known amount of work; fatigue which accompanies riding in automobiles is very largely nerve, rather than muscular, fatigue; muscular fatigue is fairly satisfactorily indicated; most promising measures of nerve fatigue which accompanies automobile riding outlined.

Suspension. Balanced Axle Suspension. Autocar (Lond.), vol. 63, no. 1762, Aug. 9, 1929, p. 277, 1 fig. Description of suspension system for automobiles designed by R. Greaves which used one spring for all four wheels.

Transmissions. Recent Progress in Speed Gear Boxes for Automobiles (Les récents progrés des boites de vitesses pour automobiles), G. Delanghe. Génie Civil (Paris), vol. 95, no. 9, Aug. 31, 1929, pp. 201–203, 10 figs. Various methods of designing gear boxes for automobiles are discussed; details of gear boxes with four combinations and third muffled speed, covering those of Panhard and Levassor, and Mathis Biflex system; Voison compound and Blério speed relays are also described.

AUTOMOTIVE FUELS

Detonation. The Influence of Cylinder Design on Pinking, G. B. Maxwell and R. V. Wheeler. Inst. of Petroleum Tech.—Jl. (Lond.), vol. 15, no. 75, Aug. 1929, pp. 415–420 and (discussion) 420–427, 4 figs. partly on supp. plate. Formation of stationary waves in gaseous explosions; inflammation of turbulent mixtures; influence of dimensions and shape of combustion space; position of source of ignition; contour of combustion space; restrictions at sensitive point in combustion space.

AVIATION

New Reduction Methods. Aerial Navigation, C. D. G. Jeffrey. Aeronautics, vol. 5, no. 4, Oct. 1929, pp. 29, 30, and 80, 8 figs. Necessity for new reduction methods in navigating air which will be less tedious, possibly a little less accurate, but more speedy; objections to use of logarithmic or other tables; use of graphical methods employing curves is explained; mechanical methods; use of Bygrave slide rule; Wimperis and Horsley slide rule based on d'Ocagne nomogram; combination of graphical and mechanical methods found in Baker's Navigation Machine.

B

BALANCING MACHINES

Krupp-Losenhausen. Krupp-Losenhausen Static and Dynamic Balancing Machines. Am. Mach., vol. 71, no. 13, Sept. 26, 1929, p. 571, 1 fig. Description of two Krupp-Losenhausen static and dynamic balancing machines equipped with magnetic means for counter-balancing outswing of unbalanced parts; electric balancing device consists of current-breaking system and for creating magnetic field double magnet which is attached to oscillating frame.

Olsen-Lundgren. Development of the New Method of Balancing Rotating Parts, C. N. Fletcher. Machy. (Lond.), vol. 34, no. 885, Sept. 26, 1929, pp. 817–819, 4 figs. Description of latest improved Olsen-Lundgren balancing machine and of transfer instrument which give it greater ease of operation and calculation; method of measuring forces quite different; micrometers take place of weights and screws; new operation procedure outlined; design of transfer instrument explained; production balancing of quantities.

Rotor. The Westinghouse Rotor-Balancing Machine. Engineering (Lond.), vol. 128, no. 3322, Sept. 13, 1929, pp. 317–319, 10 figs. Machine made by Westinghouse Electric and Mfg. Co., is capable of balancing rotor up to 30 ft. long and 15 ft. in diam. with total weight of 134 tons, rotor is carried on two bearings, which are mounted so they can oscillate in horizontal plant; machine is driven by electric motor.

BEARINGS, JOURNAL

Lubrication. Lubricating Film of Journal Bearings and Its Measurement Through Interference (Die Schmierschicht in Gleitlagern und ihre Messung durch Interferenz), R. Wolff. V.D.I. Zeit. (Berlin), vol. 73, no. 34, Aug. 24, 1929, pp. 1198–1202, 27 figs. Measuring method, mathematical analysis and practical data obtained.

BOILER FEEDWATER

Treatment. Feedwater Treatment in Steam Power Plants (Speisswasserpflege im Waermetraftbetrieb), M. Rohrlach. Waerme (Berlin), vol. 52, no. 36, Sept. 7, 1929, pp. 708–710. Notes on feedwater treatment processes and their application; best methods of feedwater degasification are discussed; vacuum degasification and high-pressure systems; cost of treatment.

BOILER FIRING

Low-Grade Fuels. Effect of Fouling on Boiler Efficiency, J. W. Pierson. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 3 pp., 5 figs. Subject considered concerns situation that confronts those in Middle West who out of necessity are required to burn some of low-grade fuels of Illinois; fouling conditions incident to use of such fuel with chain-grate firing with high relative ratings are dealt with; data presented show efficiency characteristics of operating cycle with this low grade fuel compared to that which would exist when using better fuel.

BOILER FURNACES

Water-Cooled. Economics and Design of Water-Cooled Furnaces, J. S. Bennett and P. N. Oberholtzer. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 9 pp., 16 figs. Experience of one manufacturer in designing and operating water-cooled furnaces is given; deals particularly with water-cooled furnaces for underfeed stokers, and study of results and conditions of several actual installations is presented.

BOILER OPERATION

Efficiency. Thermal Absorptivity of Heating Surfaces of Boilers and Its Influence on Their Efficiency (La "receptivité thermique" des surfaces de chauffe des chaudières et son influence sur le rendement), J. Bourdel and R. Mollard. Revue Universelles des Mines (Liege), vol. 72, no. 2, July 15, 1929, pp. 42–44. Critical discussion of factors tending to lower efficiency of central power stations, in spite of modernized construction and complexity of precise measuring instruments; notes on actual tests of Babcock and Wilcox boiler, with and without Williams vaporization system; increased yield of 5.85 per cent is indicated.

BOILER PLANTS

Fuel Economy in. Relative Economy of Pulverized Coal, Oil, and Gas as Boiler-Plant Fuels, M. Frisch. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 10 pp. Where plants are so located that several fuels are obtainable; management must determine which fuel is most economical; analysis of cost of making steam with each of available fuels is necessary, various commonly used fuels are compared as to their relative economy; influence of each fuel on overall plant performance and economy is considered; paper sums up relative plant efficiency and relative plant economy to be expected of various fuels.

BOILER PLATES

Calculation. Are the Usual Formulas for Calculating Cylindrical Jackets and Dished Heads Correct? (Sind die ueblichen Berechnungsformeln fuer zylindrische Maentel und Woelbboeden fuer Kessel richtig?), F. Von Zeipel. Waerme (Berlin), vol. 52, no. 35, Aug. 31, 1929, pp. 685–686. Formulas for thickness of plate of drum jackets for tangential, axial, and combined stresses; limit values for last-named formulas as well as for Bach's formula for high pressures; formulas for plate thickness of dished heads in case of combined stress and application of this formula according to latest code; relation between stress of longitudinal and cross sections of cylindrical jacket.

Stresses. Failures and Life of Boiler in Relation to Stresses and Strength of Materials (Schaeden und Lebensdauer der Dampfkessel in ihrer Abhaengigkeit von der Beanspruchung und Schwingungsfestigkeit der Werkstoffe), M. Ulrich. Waerme (Berlin), vol. 52, no. 30, July 27, 1929, pp. 567–574, 8 figs. Stresses in riveted boilers are considerably greater than those permissible in machinery; nevertheless life of boiler can be practically unlimited; method is proposed according to which results of vibration tests can be combined with results of observations on boilers in operation so that boiler owner may obtain idea of relation between materials stress and life of boiler.

BOILERS

Control, Electric. Automatic Electric Boiler Control (Selbsttaetige Kesselregelung auf elektrischem Wege), M. Moeller. Waerme (Berlin), vol. 52, no. 36, Sept. 7, 1929, pp. 706–707, 2 figs. Automatic control system of Siemens and Halske is described; Wheatstone bridge is used as control switch; group of boilers can be controlled by main regulator; practical tests demonstrated economic advantages of system.

Design. Most Economic Steam Pressure and Increase in Efficiency (Wirtschaftlichster Dampfdruck und Leistungssteigerung), Ebel. Waerme (Berlin), vol. 52, no. 30, July 27, 1929, p. 585. Consolidation of heating surface (by use of fewer and larger units) and increasing output are two ways of considerably reducing boiler costs per ton of steam; reduction of power costs in this way is greater than by pressure increase alone, medium pressure is most advantageous.

Electric. Mascarini A.C. Steam Boiler. Elec. Times (Lond.), vol. 76, no. 1973, Aug. 15, 1929, pp. 234–235, 2 figs. Mascarini electric boiler manufactured by Bastian Meter Co., England, for which this concern has sole rights in British Empire is described; diagrammatic layout of equipment is given.

Heat Transmission in. Heat Transfer in Steam Boilers (Warmteoverdracht in Stoomketels), H. C. A. Roosa. Polytechnisch Weekblad (Amsterdam), vol. 23, no. 32, Aug. 8, 1929, pp. 563–566, 7 figs. Various difficulties had been experienced with newly installed Babcock and Wilcox boiler with Walther chain grate and so-called additional furnace for flue dust, because furnace ceiling collapsed when some months in use; cause was expected to result from heat transfer conditions, and on the basis of an article by Von Pritzelwitz van der Horst in De Ingenieur of 1924 on the subject, improvement was obtained.

High-Pressure. Calculation of Wall Thicknesses of High-Pressure Boiler Drums (Berechnung der Wanddicken von Hochdruckkesseltrommeln), W. Baehren. Waerme (Berlin), vol. 52, no. 30, July 27, 1929, pp. 594–602, 23 figs. German official formula is given; elastic-limit formula; investigation of stresses; Torkret drum insulation.

Tests of an Atmos High-Pressure Boiler. Engineer (Lond.), vol. 148, no. 3842, Aug. 30, 1929, pp. 218–219, 1 fig. Brief description of installation of atmos boiler to drive impulse turbine; boiler, which is built for pressure of 1565 lb. per sq. in., comprises two squirrel-cage rotors, each of heating surface of 247.5 sq. ft., arranged in longitudinal direction; superheater is mounted immediately above them, and flanked on each side by one-half of feedwater heater; two halves of latter are arranged in parallel as regards water circulation, and each presents two passes in series for flue gases; the latter are delivered into steel chimney by means of an induced draft fan.

Locomotive. See LOCOMOTIVES, Boilers.

BRONZE

Properties. Characteristics of Hy-ten-sl Bronze. Am. Mach., vol. 71, no. 13, Sept. 26, 1929, p. 561 (plate no. 46), 1 fig. Description of physical characteristics of Hy-ten-sl bronze which has great strength, toughness, hardness, and resistance to corrosion, combined with good machining properties; for worm-wheel drives operating at slow to moderate speeds under heavy load and for gears subjected, two shock grade No. 3 is recommended; recommended cutting angles for machining Hy-ten-sl bronze are illustrated.

C

CABLEWAYS

Design. Suspension Lift—New Type of Cableway (Der Schwebelift, eine neue Bauweise von Luftseilbahnen), R. Petersen. Bautechnik (Berlin), vol. 7, nos. 31 and 34, July 19 and Aug. 9, 1929, pp. 477–482 and 517–520, 35 figs. Theory, features, design, and applications of author's type of cableway transporter, working on principle of endless belt; use of such cableways in ports and for mountain railways.

CARS, REFRIGERATOR

Design. Practice in Refrigerator Car Design, E. A. Sweeley. Refrig. Eng., vol. 18, no. 3, Sept. 1929, pp. 67–68 and (discussion) 68–70. Development in design of refrigerator cars has been based upon theory of ice refrigerator, temperated by service requirements and experience; greatest problems in this work has been waterproofing of floors, construction of roof and other practical considerations.

CASE HARDENING

Carburizing Material. Economical Re-use of Solid Carburizing Material, H. B. Knowlton. Automotive Industries, vol. 61, no. 12, Sept. 21, 1929, pp. 419–420. Economical re-use of solid carburizing material is discussed; in experimental work extending over two years, author found it possible to decrease addition after each run from 33 per cent to 12 per cent without change in depth of case and proportion of carbon in different zones; experimental carburizing was done in modern automatic controlled counterflow furnace; carburizer chemical content tests. Abstract of paper presented before Am. Soc. for Steel Treating.

Progress in. Progress in Case Hardening (Neuere Fortschritte auf dem Gebiete der Einsatzhaertung), A. Jaeschke. Zeit. fuer die gesamte Giessereipraxis (Berlin), vol. 50, no. 34, Aug. 25, 1929, pp. 135–137. It is claimed that advantages of calcium-cyanide baths are greatly overrated; protective value of copper, nickel, and tin against cementation varies greatly; use of Schoop metal-spray process has proved uneconomic; accuracy of method of measuring depth of case; conditions which lead to failures in case hardening.

CAST IRON

High-Test, Heat Treatment of. The Heat-Treatment of Grey Cast Iron, E. E. Marbaker. Foundry Trade Jl. (Lond.), vol. 41, no. 680, Aug. 29, 1929, pp. 153–155. Results of various investigations dealing with heat treatment for improving properties of castings; influence of time element; low-temperature annealing for removal of strains in castings; high-temperature annealing to influence changes in structure.

Superheating. Superheating of Cast Iron (Die Ueberhitzung von Gusseisen), P. Bardenheuer and K. L. Zeyen. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf (Duesseldorf), vol. 11, no. 13, 1929, pp. 225–235, 74 figs. on supp. plates. See also Giesserei (Duesseldorf), vol. 16, no. 33, Aug. 16, 1929, pp. 733–746, 74 figs. on supp. plates. Application of superheating charge to graphite refining, influence of superheating temperature on grain formation; distribution of mixed crystals and graphite eutectoid; relations between chemical composition, structure, and mechanical properties; methods of preventing deleterious effect of superheating on structure and mechanical properties.

CHAIN DRIVE

Variable-Speed. Variable-Speed Drives for Long Conveyor Chains, R. W. Drake. Indus. Eng., vol. 87, no. 9, Sept. 1929, pp. 439–443, 6 figs. Discussion of control equipment, together with essential data on layout of variable-speed conveyor chain drives employing two or more d.-c. motors; horsepower required to drive conveyor chains; variable-speed chain installations.

CHROMIUM STEEL

Welding. Welding Rustproof Steels, W. Hoffmann. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 531, Sept. 1929, 9 pp., 18 figs. on supp. plates. Results of experiments with two chrome-steel and two chrome-nickel-steel sheets; rustproof steels easily welded by acetylene-oxygen process; welding rods must be protected in arc welding; hardness resulting must be removed by thermal treatment; owing to its loss in carbon, silicon, and manganese, steel melted in gas flame or electric arc is more rustproof. Bibliography. Paper presented before German Acetylene Society and published in Autogene Metallbarbeitung, Dec. 15, 1927.

CLUTCHES

Magnetic. Magnetic Clutches, C. H. S. Tupholme. Mech. World (Manchester), vol. 86, no. 2227, Sept. 6, 1929, pp. 220–221, 3 figs. Advantages of magnetic clutch for connecting prime movers to driven machinery, particularly where space along shafts is limited, or where clutch must be placed in almost inaccessible position; design and operation of clutch; application to fan drives for ventilation purposes in Liberty Tunnel at Pittsburgh; proper method for selecting clutch.

COLD-STORAGE PLANTS

Tampa, Fla. A Modern Southern Refrigeration Fortress, M. Price. South. Power Jl., vol. 47, no. 9, Sept. 1929, pp. 50–55, 3 figs. Description of combined use of brine and fresh water spray air washing and direct expansion in serving demands for refrigeration and processing in outstanding Florida terminal plant; description and list of plant equipment.

CONVEYORS

Monorail. Fundamentals Which Should Be Observed in Design and Application of Tramrail Systems, E. T. Bennington. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 21–23, 1929, 5 pp., 11 figs. There are many fundamental principles of design for overhead conveying machinery that cannot be safely overlooked if system is to be subjected to severe service; even if it is not to be subjected to severe service, from standpoint of safety and ease of handling these principles should all be understood and observed; this paper contains only a few of more important principles of design and application.

COREMAKING

New Methods. Ford Introduces New Coremaking Methods, P. Dwyer. Foundry, vol. 57, no. 18, Sept. 15, 1929, pp. 772–776 and 783, 10 figs. Description of new coremaking methods employed in Ford Motor Co. foundry at River Rouge with details of foundry buildings; method is contrary to universal practice in ingot mold foundries which has been to form mold and core in upright position; in Ford plant they are molded horizontally and cast vertically; cores are hard in center and soft on outside.

COUPLINGS

Flexible. The "Carrier-Ring" Flexible Coupling. Engineer (Lond.), vol. 148, no. 3845, Sept. 20, 1929, p. 312, 8 figs. In coupling described, ends of shafts are each provided with spider resembling spur wheel with deeply cut teeth; these spiders are united by number of flat steel springs, which fit within gaps of spider teeth and which are mounted on central carrier ring to constitute single unit; two cover rings bolted together embrace and enclose two spiders and carrier unit.

CRANES

Luffing. Luffing Cranes (Der Wippkran), O. Wundram. Werft Reederei Hefen (Berlin), vol. 10, no. 9, May 7, 1929, pp. 179–180, 5 figs. New type of crane introduced into Germany has as characteristic feature, in distinction from other crane types, advantage that unloading of its movable jib between two end positions (minimum and maximum radius) can be changed rapidly and under full load.

Traveling. Traveling Cranes in Link-Belt and Cut-Stone Plants, W. T. A. Bell. Can. Machy. (Toronto), vol. 40, no. 19, Sept. 19, 1929, pp. 114 and 118–120, 8 figs. Description of traveling-crane equipment installed in new plant of Link-Belt, Ltd., Toronto, Ritchie Cut Stone Co., Toronto, Scott Bros., and other cut-stone manufacturers are described.

CUPOLAS

Linings. Plastic Linings for Cupolas, G. H. Zirker. Foundry Trade Jl. (Lond.), vol. 41, no. 682, Sept. 12, 1929, pp. 194–196. Results of investigation made by German Association of Foundrymen and Union of German Iron Foundries into possibilities and advantages of rammed linings as compared with brick linings; chemical composition of plastic refractories; behavior when subjected to heat; practical operating and ramming details; tools used; drying out; repair work; selection of staff; results obtained from four different iron foundries, tests being taken on non-receiver types of furnace. Translated and condensed from a recent issue of Giesserei.

CUTTING TOOLS

Chromium Plating of. Development in Chromium Plating, L. Wright. Machy. (Lond.), vol. 34, no. 881, Aug. 29, 1929, pp. 680–682. Various properties of chromium plated coatings and application of chromium plating to cutting and press tools, dies, molds, gages, and machine parts are discussed; results of tests of twist drills and hacksaw blades.

D

DIE CASTING

Automatic Dies. Intricate Castings from Automatic Dies, J. B. Nealey. Iron Age, vol. 124, no. 15, Oct. 10, 1929, pp. 968–969, 2 figs. Discussion of methods employed by Alemite Die Casting and Manufacturing Co., Chicago, for making wide variety of die castings are described; company pays special attention to insets, placing and withdrawing cores, and gating and venting dies; company's plant at Woodstock, Ill., used for manufacture of full line of cast aluminum cooking utensils, also described.

DIESEL-ELECTRIC POWER PLANTS

Industrial. Diesel Plant Shows Marked Economy, E. J. Kates. Iron Age, vol. 124, no. 15, Oct. 10, 1929, pp. 970–971, 1 fig. Description of Diesel-electric power plant installed by Vulcan Rail and Construction Co., Maspeth, N. Y., manufacturers of structural and ornamental iron; power unit is 240-hp. 6-cylinder Diesel engine direct connected to 160-kw. generator; minimum amount of supervision required; table shows operating cost of 160-kw. Diesel power plant for 7 months.

DIESEL ENGINES

Marine. The Highest Powered Marine Diesel. Gas and Oil Power (Lond.), vol. 26, no. 288, Sept. 5, 1929, p. 240, 1 fig. Feature of new Atlantic passenger liner of White Star line is 10,000 b.hp. Diesel, which has completed shop trials; unit is double-acting, four-stroke, Harland B. and W. type with cylinders cooled with water and pistons with lubricating oil; four separate injection air compressors, driven by four-cylinder trunk-piston engines of same make; general description of equipment.

Standardization. Rationalization and Standardization in Construction of Diesel Engines (Rationalisierung und Normalisierung im Dieselmotorenbau), O. F. Bruman. Schweizerische Bauzeitung (Zurich), vol. 94, no. 8, Aug. 24, 1929, pp. 90–91, 2 figs. General discussion of problems; methods and standards developed by Ref Apparatebau-Gesellschaft of Stuttgart-Feuerbach.

Supercharging. Capacity Increase of Diesel Engines According to the Buechi Supercharging System (Die Leistungssteigerung von Dieselmotoren nach dem Buechi-Verfahren), A. Buechi. Ingenieur (Hague), vol. 44, no. 35, Aug. 31, 1929, pp. W. 135–W. 166, 33 figs. Notes on various supercharging methods and explanation of characteristics of Buechi exhaust-gas turbine supercharging; comparison of pressure, temperature, and loading conditions with regard to four and two-cycle Diesel engines; results with engines of various sizes and speeds, including constructive details, dimensions, and weight, compared with present types.

Two-Cycle. A New Two-Cycle Diesel. Gas and Oil Power (Lond.), vol. 24, no. 288, Sept. 5, 1929, p. 235, 1 fig. General description of new "K3M" series of engines manufactured by Atlas Diesel Co., Ltd.; cylinders made in monobloc, bolted in vertical plane and secured to bed plate by long tie bolts; new positive scavenging system; unusual feature is pneumatically controlled starting valves.

E

ELECTRIC FURNACES

Foundry. 500 Kw.-Hr. per Ton for Steel Castings, D. T. Waby. Elec. World, vol. 94, no. 12, Sept. 21, 1929, p. 574. Steel foundry in Middle West melted more than 23,000 tons of steel in one furnace in three years with average consumption of 500 kw.-hr. per ton; author points out that average charge per heat was 5.8 tons and average time between heats 10.2 min.; table showing three years' record of large electric steel foundry.

Galvanizing. Electric Galvanizing Equipment Proves Its Advantages in Edison Shops, A. D. Irion. Elec. West, vol. 63, no. 3, Sept. 1, 1929, pp. 124–125, 2 figs. Advantages of electric heat for galvanizing pot and tabulation of test data covering three-day period of operation of electric galvanizer under average shop conditions.

ELECTRIC WELDING ARC

Atomic-Hydrogen. The Welding of Ferrous and Non-Ferrous Metals by the Atomic-Hydrogen Flame, R. A. Weinman. Gen. Elec. Rev., vol. 32, no. 10, Oct. 1929, pp. 532–537, 16 figs. Characteristics of atomic hydrogen flame which make it exceptionally useful tool in welding tungsten, molybdenum, cast iron, alloy steels, aluminum and its alloys, brass, and nickel; equipment and its operation.

Automatic. Automatic Thin-Sheet Arc Welding, W. L. Warner. Iron Age, vol. 124, no. 13, Sept. 26, 1929, pp. 834–837, 13 figs. Requirements of fusion welding are taken up; importance of suitable clamping apparatus and procedure for welding thin sheet metal successfully are discussed; magnetic effect produced by electric current passing through arc must be controlled; how flux operates and how it is handled; electro-magnetic control scheme developed by General Electric Co.; applications of automatic arc welding. Abstract of paper presented before Am. Welding Soc. and A.S.M.E.

EVAPORATORS

Use in Process-Steam Generation. Evaporators in New Application Generate Process Steam. Power, vol. 70, no. 9, Aug. 27, 1929, pp. 335–337, 4 figs. Important movement in process-steam engineering is that evaporators are installed to take large percentage of entire boiler output, return distilled condensate to feed lines and deliver pure vapor to process; evaporator arrangements in process plants; heat balance diagram with reducing valve evaporator.

F

FORGINGS

Steel. The Effect of Reduction from Ingot to Forging in Steel Forgings, L. H. Fry. Am. Soc. Testing Matls.—Reprint from Proc., vol. 29, pt. 2, 1929, 11 pp., 8 figs. Summary of investigations carried out by sub-committee of Committee A-1 on steel to ascertain how properties of steel forgings are affected when variation is made in amount of reduction between ingot and forging; work done by other investigators is considered; it is concluded that it is unnecessary to specify amount of reduction to be made between ingot and forging, but that in specifications for blooms requirement of three to one reduction from ingot to bloom may be justified.

FOUNDRY PRACTICE

Mass Production. Modern Gray Iron and Steel Foundry for Mass Production, L. W. Spring. West. Soc. of Engrs.—Jl., vol. 34, no. 9, Sept. 1929, pp. 520–529. Condensed review of modern practices with certain amount of elementary description to make it complete; new requirements due to high pressure, particularly in oil refineries and power plants, have caused engineers to specify steel castings for many parts formerly made of cast iron; comparison of physical properties of two materials given shows why.

FUEL

Oil. See OIL FUEL.

FURNACES, ANNEALING

Continuous. Modern Annealing Furnaces for Continuous Production in Automobile Plants (Neuzeitliche Gluehoefen fuer Fliessende Fertigung in Motorfahrzeugfabriken), H. Reiniger. Automobiltechnische Zeit. (Berlin), vol. 32, no. 23, Aug. 20, 1929, pp. 506–509, 16 figs. Main requirements of annealing furnaces for continuous production are characterized, and few types are described which have proved satisfactory.

FURNACES, HEAT TREATING

Conveyors. Thirteen Classes of Mechanisms Convey Metal Through a Furnace. E. G. de Coriolis. Iron Age, vol. 124, no. 15, Oct. 10, 1929, pp. 960–962, 5 figs. Description of reliable mechanisms for conveying metals through heat-treating furnaces; conveyor belt for use in heat treatment of small parts; rotary-hearth furnaces combine many advantages not possessed by other types; rotary cylinders; limitations of spiral.

G

GALVANIZING

Pickling. Pickling Principles in Galvanizing, W. G. Imhoff. Iron Age, vol. 124, no. 15, Oct. 10, 1929, pp. 957–959, 3 figs. Results of test in pickling and galvanizing water pails; conditions affecting steel surfaces; rolling sheet bars out into sheets; doubling sheets into packs; putting finish on black plate; rolling sheets without using heat; different results from annealing; making pails from annealed sheets; pickling tests proved that the longer the pickling time, the heavier will be the zinc coating deposited.

GAS ENGINES

Efficiency. Effect of Heat Transmission on the Indicated Efficiency of a Gas Engine (Der Einfluss des Waermeueberganges auf den indizierten Wirkungsgrad der Gasmachine), E. Hecker. V.D.I. Zeit. (Berlin), vol. 73, no. 38, Sept. 21, 1929, pp. 1357–1359, 6 figs. Discussion of Nusselt formula for computation of heat transmission; curves showing temperature during expansion; effect of wall temperature, engine capacity, etc., on thermal and indicated efficiencies. Excerpt from bulletin no. 316 of Forschungsarbeiten auf dem Gebiete des Ingenieurwesens published by Verein deutscher Ingenieure.

Indicated Efficiency of Gas Engines (Der indizierte Wirkungsgrad der Gasmaschine), H. Schnell. V.D.I. Zeit. (Berlin), vol. 73, no. 38, Sept. 21, 1929, pp. 1349–1350, 1 fig. Criticism of A. Witz's formula and development of author's set of formulas; numerical example; excerpt from Bulletin no. 316 of Forschungsarbeiten aus dem Gebiete des Ingenieurwesens, published by Verein deutscher Ingenieure.

Manufacture. Variety No Bar to Mass Production. Iron Age, vol. 124, no. 12, Sept. 19, 1929, pp. 723–729, 11 figs. Methods employed by Waukesha Motor Co. in producing 30 different models of gas engines at prices that reflect mass production; operations departmentalized both as to parts and size of completed product; in building smaller engines flow of material makes complete circle from unloading platforms through various departments to shipping room; straight-line flow of materials characterizes building of Big Four larger models; material-handling problem given special study; special testing machine devised for connecting rods.

GEARS

Heat Treatment. Steel for Highly Stressed Gears, H. W. McQuaid and O. W. McMullen. Automotive Industries, vol. 61, no. 12, Sept. 21, 1929, pp. 417–419, 2 figs. Selection of case-hardening steels for highly stressed gears is discussed; it is recommended that ring gears be made from bar stock by upsetting, rather than from flat stock, in order to assure best flow lines; test results from number of different case-hardening steels; depth hardness curve obtained by means of Vickers diamond is extremely valuable; method of testing deserves to be more extensively used. Abstract of paper presented before Am. Soc. for Steel Treating.

Reduction. A 10,000 to 1 Reduction Motion, W. E. Sykes. Am Mach., vol. 71, no. 11, Sept. 12, 1929, p. 426, 5 figs. Description of device which gives reduction of 10,000 to 1 with four gears of practically same size; it is external adaptation of differential principle used in some chain hoists, but has advantage over internal type in that there is only tooth difference between gears.

GRINDING MACHINES

Cutter. Automatic Cutter Grinder with Grinding Pressure Regulation. Machy. (Lond.), vol. 34, no. 881, Aug. 29, 1929, pp. 697–700, 8 figs. Description of automatic cutter grinder built by Grossenhainer Webstuhl- u. Maschinenfabrik, Grossenhain, Germany; hand adjustment of cutter to be ground toward grinding wheel, to compensate for wear, has been done away with and replaced by automatically and evenly acting grinding pressure regulation; working cycle takes place automatically; by means of special vertical control, spaces between worn out teeth can also be automatically deepened.

H

HANGARS

Airplane. Airplane Hangars, W. S. Miles. Aviation Eng., vol. 2, no. 9, Sept. 1929, pp. 15–18, 4 figs. Problems to be solved, in design

of airplane hangars; laying out air terminals; airport economics; practice of Pan-American Airways, Curtiss companies, and New York Air Terminals in constructing hangars; roof loads, doors, lighting, and heating are taken up; buying hangars; hangar contracts.

HARDNESS

Tests for. A Synopsis of the Present State of Knowledge of the Hardness and Abrasion Testing of Metals with Special Reference to the Work Done During the Period 1917–27, and a Bibliography. G. A. Hankins. Instn. Mech. Engrs.—Jl. (Lond.), no. 2, Mar. 1929, pp. 317–373 and (discussion) 374–387, 4 figs. Synopsis covers following test; Brinell, diamond indentation, steel cone indentation; Haigh prism; Herbert pendulum hardness, dynamic indentation; abrasion or wear; diamond scratch hardness, Hertzian hardness, magnetic hardness.

HEAT TRANSMISSION

Radiation Formulas. Notes on Some Radiation Heat Transfer Formulae. O. A. Saunders. Phys. Soc.—Proc. (Lond.), vol. 41, no. 239, Aug. 15, 1929, pp. 569–575, 1 fig. General expression for radiation heat transfer from surface is first considered after which some simple cases are examined, i.e., parallel planes, concentric spheres, etc.; some general conclusions are then drawn for case of surface completely surrounded by other surfaces at uniform temperatures, but of no particular simple shape.

HELICOPTERS

Flying Principles of. The Story of Vertical Flight. E. W. Fair. Aeronautics, vol. 5, no. 3, Sept. 1929, pp. 15–16 and 67–68, 9 figs. Discussion of helicopter flight principles is preceded by explanation of de Cierva's autogiro; Froude momentum theory; helicopters to date have been unable to carry much more weight than that of pilot himself because of lost thrust-power ratio; requirements listed by A. Klemin for successful helicopter and his prediction regarding lines of development which helicopter will follow are quoted.

HELIUM TANKS

Testing. Wreck Railroad Car to Test Helium Tank Mounted on It. Iron Age, vol. 124, no. 13, Sept. 26, 1929, p. 840, 3 figs. Results of staged train wreck and hydrostatic pressure test recently applied to type of spherical vessel built by A. O. Smith Corp. for transportation of helium gas; under steady hydrostatic pressure of 4500 lb. per sq. in. vessel finally failed; in no place did break follow weld.

HYDRAULIC LABORATORIES

Germany. Hydraulic Machines Testing Laboratory of the Karlsruhe Institute of Technology (Das Institut fuer Stroemungsmaschinen an der Technischen Hochschule Karlsruhe), W. Spannhake. V.D.I. Zeit. (Berlin), vol. 73, no. 36, Sept. 7, 1929, pp. 1280–1282, 6 figs. Details of equipment and methods used in testing of turbine wheels and pumps by means of models.

HYDRAULIC TURBINES

Propeller-Type. Propeller-Turbine Set at Forshuvudforsen, Sweden. Engineering (Lond.), vol. 128, no. 3233, Sept. 20, 1929, pp. 375–378, 8 figs. Description of third turbine installed in Forshuvudforsen power plant; it develops 10,200 h.hp. on same head, at speed of 94 r.p.m.; it is Lawaczeck type; runner is 4240 mm. in diam., and has six blades cast separately and bolted to runner boss; guides ring has 28 guide blades of cast steel, each supported on ball bearing.

I

ICE

Heat Conductivity of. Heat Conductivity of Ice (Das Waermeleitvermoegen des Eises), S. Arzybyschew and O. Parfianowitsch. Zeit. fuer Physik (Berlin), vol. 56, nos. 7–8, July 29, 1929, pp. 441–445, 3 figs. Report from Institute of Biology and Geography of Irkutsk, Siberia, on new determination of heat conductivity of ice which gave value of 0.0055 calories per centimeter per second.

INTERNAL-COMBUSTION ENGINES

[See AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON

Brittleness of. Fracture of Iron at Low Temperatures (Ueber den Bruchvorgang in Eisen bei tiefen Temperaturen), F. Sauerwald and K. A. Pohle. Zeit. fuer Physik (Berlin), vol. 56, nos. 7–8, July 29, 1929, pp. 576–578, 1 fig. Report on experimental study, by Department of Metallurgy of Breslau Institute of Technology, on nature of brittleness of iron at temperatures between zero and minus 170 deg. cent.

K

KEYS AND KEYWAYS

Standardization. The Standardization of Keys and Keyways. W. Reavell. Instn. Mech. Engrs.—Jl. (Lond.), no. 2, Mar. 1929, pp. 277–302 and (discussion) 303–315, 26 figs. History of standardization under British Engineering Standards Association; results of tests with steel shafts of high tensile strength; tables of dimensions and tolerances for rectangular parallel keys.

L

LATHES

Multiple-Spindle Chucking. New Multiple-Spindle Chucking Machine. Iron Age, vol. 124, no. 11, Sept. 12, 1929, pp. 681–682, 2 figs. Description of work-rotating multiple-spindle chucking machine designed by Goss and De Leeuw Machine Co., New Britain, Conn.; four work spindles set radially, 90 deg. apart, in horizontal turret present work to three sets of tools for simultaneous operation; work spindles driven by 25-hp. motor; drive for turret indexing and all feeds on main tool slides and cross slides furnished by 5-hp. motor.

LIFTING MAGNETS

Employment of. Electric Lifting Machines. J. A. Smeeton. Shipbldg and Shipg. Rec. (Lond.), vol. 34, no. 11, Sept. 12, 1929, pp. 304–305, 3 figs. Practical use of magnets is rapidly developing, and their extended employment, especially in iron and steel industry, will result in large reduction in labor costs for general handling, which will enable users appreciably to reduce their on-costs, and accordingly their selling prices; special research is now being made and patents will be applied for by which magnets can be worked with alternating current as efficiently as with direct current.

LIGHTING

Industrial. Industrial Lighting (Industriebeleuchtung). W. Ruffer. V.D.I. Zeit. (Berlin), vol. 73, no. 38, Sept. 21, 1929, pp. 1361–1364, 3 figs. Principles of design of lighting systems for industrial plants and shops; physiological and psychological effects of lighting on efficiency of workers; economics of lighting discussed with special reference to work of Clewell and Luckiesh.

LOCOMOTIVE REPAIR SHOPS

Machine Tools. Superheater-Unit Repair Equipment. Am. Mach., vol. 71, no. 14, Oct. 3, 1929, pp. 588–589, 7 figs. Many devices of labor-saving nature, used at Albuquerque shops of Atchison, Topeka and Santa Fe Railway System for repairing and testing superheater units, are illustrated in seven halftones each accompanied by brief description.

LOCOMOTIVES

Boilers. Locomotive Boiler Power Rating. T. Grime. Ry. Engr. (Lond.), vol. 50, no. 596, Sept. 1929, pp. 346–348 and 359, 1 fig. Definite basis for determination of cylinder and boiler performance; heating surface as basis of evaporative power; efficiency of tubes; combustion efficiency; diagram showing absorption overall and combustion efficiencies, and evaporation at various firing rates.

Frames. Rebuilt Consolidation Type Locomotives Chicago Great Western Railroad. E. J. Brennan. Baldwin Locomotives, vol. 8, no. 2, Oct. 1929, p. 38. New frame design has been applied to group of Consolidation type locomotives and has proven its value; class G-4 locomotives have cylinders 26 in. by 30 in., drivers 63 in., steam pressure of 200 lb. per sq. in., tractive force with booster 68,800 lb., total engine weight 240,500 lb.

Freight. Reading Builds Heavy 2–10–2 Type Locomotives. Ry. Mech. Engr., vol. 103, no. 9, Sept. 1929, pp. 546–548, 2 figs. Conversion of Mallet compound 2–8–8–2 type locomotive to 2–10–2 type; cylinders 30½ in.; driving wheels 61½ in.; steam pressure 220 lb. per sq. in.; tractive force 90,500 lb.; total weight of engine in working order 439,900 lb.; total engine wheelbase 42 ft. 1 in.

Oil-Electric. New C. N. R. Oil-Electric Locomotive. Can. Engr. (Toronto), vol. 57, no. 13, Sept. 24, 1929, pp. 435–436, 2 figs. Canadian National Railways put in service oil-electric locomotive No. 9000 consisting of two units weighing 310 tons and equipped with Beardmore crude oil engines and Westinghouse electrical apparatus for high-speed passenger service.

Oil-Electric Locomotives in Canada. Modern Transport (Lond.), vol. 21, no. 547, Sept. 7, 1929, pp. 10–11, 4 figs. Long-distance tests of Canadian National Railway Co.'s new oil-electric locomotives; test showed that 4 lb. of fuel oil produces same amount of power as 7 lb. of gasoline, while oil-electric heat unit performs seven times as much work as heat unit of steam locomotives; units contain 12-cylinder oil engine of solid injection, 12 in. by 12 in., normal rating 1330 hp. at 800 r.p.m.; general description of frame and trucks; electric generator and brake equipment.

Pulverized-Coal-Burning. A New Pulverized Fuel Burning System for Locomotives. Ry. Gaz. (Lond.), vol. 51, no. 11, Sept. 13, 1929, pp. 390–391, 3 figs. Experimental work recently performed by locomotive fitted with new pulverized fuel burning system has given very satisfactory results; details of construction.

The Application of Pulverized Fuel to Locomotives. J. W. Beaty. Junior Instn. of Engrs. Jl. (Lond.), vol. 39, no. 11, Aug. 1929, pp. 492–516 and (discussion) 516–518, 17 figs. Results of tests made by A.E.G. Co. on one of German State Railway locomotives with pulverized fuels; method of using pulverized fuel; experimental boiler; to obtain quicker combustion it appeared necessary to divide fuel mixture into number of jets; heating up from cold, operation, and shutting down; special features of A.E.G. locomotive; advantages to be gained from use of pulverized fuel; Henschel locomotive.

Speed Indicators. A New Type of Locomotive Speedometer. Ry. Gaz. (Lond.), vol. 51, no. 11, Sept. 13, 1929, pp. 394–395, 1 fig. Rezny apparatus is of indicating and recording type and is suitable for all conditions of locomotive service; general description of apparatus.

Wiesinger High-Efficiency. High-Efficiency Locomotive Wiesinger System. Locomotive (Lond.), vol. 35, no. 445, Sept. 14, 1929, pp. 299–300, 1 fig. After 19 years of preliminary study K. Wiesinger evolved first designs for 4–4–0 express locomotive of 1200 hp.; intended to develop 2000 hp., adaptable for hauling fast goods trains at 35 m.p.h. or express passenger up to 75 m.p.h.; construction and arrangement of nests of tubes have been specially designed; claim of 80 per cent efficiency; main engine consists of two rows of six single-acting cylinders, 7⅞ in. by 11¹³/₁₆ in. steam pressure 600 lb. per sq. in.; diagram giving thermal efficiency of system.

M

MACHINE TOOLS

Accident Prevention. Making Machine Tools Safe. L. D. Burlingame. Iron Age, vol. 124, no. 14, Oct. 3, 1929, pp. 895–896. Much remains to be done to make tools safe, especially along line of educating workmen to use safe methods in carrying on their work; adequate protection should be given at cutting point, most dangerous and most difficult of all to guard; automatic operation reduces accident hazard; fool-proof guarding necessary; importance of guarding against flying chips; accidents reduced 50 per cent by foremen's cooperation. Abstract of paper presented before Nat. Safety Congress.

Design. Machine-Tool Construction in Different Countries (Vom Werkzeugmaschinenbau des Auslandes). Haeneke. Maschinenbau (Berlin), vol. 8, no. 18, Sept. 19, 1929 (Betrieb), pp. 611–618, 29 figs. Review of modern design based on exhibits of Leipzig Fair; trends in United States, England, and Switzerland are discussed.

Power Requirements. Power Required for Feeding Tools. Machy. (Lond.), vol. 34, no. 881, Aug. 29, 1929, p. 683. Calculation of power required for operating feeding motions of machine tools, more particularly those of milling machines is discussed; determining permissible windup between power input and output of feed; maximum power required for feeding.

Special. Special Machine Tools (Sonder Werkzeugmaschinen), O. Vom Bovert. Werkstattstechnik (Berlin), vol. 23, no. 16, Aug. 15, 1929, pp. 469–474, 19 figs. Reasons for their procuration; characteristics of design; funda-

mentals of economic calculations; examples of machinery made, drives, etc.

Speed Control. An Electrically Controlled Gear Shift, F. A. Pearson. Machy. (N. Y.), vol. 36, no. 2, Oct. 1929, pp. 155–158, 5 figs. Description of automatic radial engagement of worm and spiral gearing which furnishes slow forward and fast return speed; planetary gearing permits electrical control; practical application of gear shift; power for driving and shifting delivered from one source; ready engagement of gear teeth assured; arrangement of electrical control.

MACHINERY

Lubrication. Lubricating Mechanisms, A. F. Brewer. Am. Mach., vol. 71, no. 11, Sept. 12, 1929, pp. 421–425, 4 figs. Discussion of advantages and disadvantages of various modern devices for applying oil and grease; centralized pressure lubricating systems and mechanical force-feed oilers; piston and plunger pumps used for lubricators; spring type of grease cup and power driven greasing device also considered; gear pumps.

Manufacturing Costs. Dependence of Total Costs and Cost Per Piece on Number of Pieces (Abhaengigkeit der Gesamtkosten und Stueckkosten von der Stueckzahl), P. Grodzinski. Maschinenbau (Berlin), vol. 8, no. 15, Aug. 1, 1929, pp. 513–517, 15 figs. Graphical and arithmetical analysis of problem from which method is developed to solve difficult interrelation; it is proven that interrelations developed play important part in Ford's manufacture method.

MALLEABLE-IRON CASTINGS

Annealing. Shortens Annealing Time in Malleableizing. Iron Age, vol. 124, no. 12, Sept. 19, 1929, p. 776. New short-cycle annealing process for production of malleable iron castings is briefly discussed; details of method worked out in Erie foundry of General Electric Co.; tests show tensile strength, yield point and other characteristics are practically same with short-cycle anneal as with older methods.

Production of. Metallurgical Principles Underlying the Production of High-Grade Malleable Castings (Die metallurgischen Grundlagen zur Erzeugung eines hochwetigen Tempergusses), R. Stotz. Giesserei (Duesseldorf), vol. 16, no. 36, Sept. 6, 1929, pp. 839–845, 14 figs. Metallurgical advantages and disadvantages in melting of malleable iron in crucible, open-hearth furnace, electric furnace, cupola and reverberatory furnace; metallurgical principles underlying tempering and its advantages over expensive cementation.

MATERIALS HANDLING

Automobile Plants. See AUTOMOBILE PLANTS.

Rubber Factories. Materials Handling in the Plant of the Goodyear Tire and Rubber Company, C. C. Stuber. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 3 pp. In plant described, 964 people are kept busy transporting average of 1,863,269 lb. of material in process of manufacture over floor space of 6,443,419 sq. ft. by use of 17,000 electric power trucks, industrial hand trucks, and platform skids; this equipment would make train 19 miles long; there are 81 elevators and 29,654 ft. of conveyors; industrial trucks are under centralized control.

Skid Platforms. How Skid Platforms and Lift Trucks Reduce the Cost of Physical Distribution, C. B. Crockett. Distribution Economy, vol. 1, no. 1, Oct. 1928, pp. 39–43, 9 figs. Examples of use of skid platforms and savings resulting.

Wage-Payment Plans. Incentive Payment Plans for Material Handling, C. A. Fike. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 21–23, 1929, 3 pp. Methods used in installing payment plans on two different phases of material-handling activities at East Pittsburgh plant of Westinghouse Electric and Manufacturing Co. are described; first phase is that of industrial electric trucking, other is material-supply group in motor-manufacturing department; brief description of work, together with detailed formulas used in installation, is included.

METAL CUTTING

Oxygen-Jet. The Godfrey Oxygen-Jet Cutting Machine. Engineering (Lond.), vol. 128, no. 3324, Sept. 27, 1929, pp. 407–408, 6 figs. partly on p. 406. General characteristic may be said to be that of embodying devices enabling precision of control to be obtained in same way that ordinary modern machine tool may be set to perform its operations accurately and in unvarying manner; machine is designed to cut metal up to 9 in. in thickness; torch can be set at any angle when plain cutting is being done, if beveled edge is required by means of a quadrant gear.

METALS

Cohesion. Cohesion and Atomic Structure, S. Dushman. Am. Soc. Testing Matls.—Proc., vol. 29, part 2, 1929, 58 pp., 15 figs. While theory of cohesion in solids based upon atomic structure has not yet been formulated, it is possible to calculate magnitude of cohesive forces by introducing plausible assumptions regarding laws of attraction and repulsion between atoms; cohesive forces calculated on basis of this theory are found to be from ten to one hundred times greater than rupture strengths actually observed.

Fatigue. Some Results of Fatigue Tests of Metals, A. Ono. Soc. Mech. Engrs.—Jl. (Tokyo) vol. 32, no. 148, Aug. 1929, pp. 331–341, 10 figs. Two different kinds of repeated stress experiments were made subjects of present note; one experiment refers to cast iron, of which fatigue resistance under repeated tensile stress was compared with that under repeated bending stress; another experiment refers to fatigue resistance of steel under repeated bending stress applied with or without simultaneous action of steady torsional stress; these experiments show that stress at point of material cannot be taken as criterion of strength; nature of fatigue failure is briefly discussed to elucidate results of experiments. (In English.)

The Work of Rupture in Relation to Fatigue. Metallurgist (Supp. to Engineer, Lond.), Aug. 30, 1929, pp. 124–125. Review of work by K. Ljungberg, main feature of which is discovery that work per unit volume required to fracture specimen at any particular section is constant, irrespective of whether work is applied in single stage or number of stages.

Finishing. Durability of Metal Finishes, R. F. Cohn. Metal Cleaning and Finishing, vol. 1, no. 4, Aug. 1929, pp. 331–334. Suitability of metal finishes and reasons for their failure are discussed; results of exposure to atmosphere, salt spray, sea water; internal reactions within coating; effect of light, shape of article, and of mechanical and temperature changes.

MOLDS, FOUNDRY

Stresses in. Calculation of Casting Stresses on Molds and Cores (Calcul des efforts à la coulée sur les moules et les noyaux), J. Pillon. Fonderie Moderne (Paris), vol. 23, June 10, 1929, pp. 229–234, 27 figs. Principles involved in causes of stresses set up in molds and cores during casting are discussed, with special reference to those in joints and separators; Pascal's law applied to pressures set up in molds; calculation of vertical and horizontal stresses in molds and cores. Paper recently presented before Conference of Union des Industries Métalliques et Minières.

N

NICKEL STEEL

Low-Expansion. Low-Expansion Nickel Steel, T. F. Russell. Engineering (Lond.), vol. 128, no. 3324, Sept. 27, 1929, pp. 400–402, 8 figs. Examination of two theories put forward to explain low-expansion anomaly, and to see to what extent characteristics of 36 per cent nickel steel may be anticipated from known behavior of iron or mild steel; gives conclusions based on tests.

NITRIDATION

Equipment for. Present Status of Nitrided Steels, H. A. De Fries. Iron Age, vol. 124, no. 13, Sept. 26, 1929, pp. 841 and 874. Five different grades of chromium-molybdenum-aluminum steel now produced by Krupp in Germany for nitriding; manufacture and properties of Nitralloy, preliminary heat treatment, hardening practice, applications, and expected developments are discussed; hardening and drawing before machining; simple equipment required for nitriding operations; outlets in automotive and steam industries.

NON-FERROUS ALLOYS

Properties and Applications. Non-Ferrous Metals and Alloys. Soc. Automotive Engrs.—Jl., vol. 25, no. 3, Sept. 1929, pp. 305–306. Information on non-ferrous metals and alloys which is not ready for incorporation in specification form is given by Non-Ferrous Metals Division of Standards Committee; properties and applications of non-ferrous cutting tools and die materials described including Stellite, cemented tungsten carbide, and Elkonite; tungsten and platinum used in automotive ignition systems and incandescent lamps.

O

OIL ENGINES

McLaren-Benz. The McLaren-Benz High-Speed Airless-Injection Engine. Engineering (Lond.), vol. 128, no. 3323, Sept. 20, 1929, pp. 393–394, 2 figs. Description of direct-reversing six-cylinder marine-pattern engine of stationary type; four-cylinder engine 160 b.hp. when running at 320 r.p.m.; cylinders are 250 mm. in diam. by 400 mm. stroke, and rated consumption is 0.4 lb. of oil per b.hp. per hour; six-cylinder engine is 180 b.hp. and runs at 500 r.p.m.; cylinders are 200 mm. in diam. by 300 mm. stroke; rated oil consumption is 0.44 lb.

OIL FUEL

Properties. Relationship Between Calorific Value and Other Characteristics of Residual Fuel Oils and Cracked Residuums, W. F. Faragher, J. C. Morrell, and J. L. Essex. Indus. and Eng. Chem., vol. 21, no. 10, Oct. 1929, pp. 933–941, 6 figs. Authors find that relationship between calorific value in B.t.u. per pound and American Petroleum Institute gravity of cracked residuums is linear; they confirm also linear relationship for uncracked fuel oils that have been reported by several other investigators; new formulas for calculating calorific value per pound of dry oil were determined; some information was obtained on composition of B.S. (Bunker "C" Specification), material present in cracked residuums.

OIL SEPARATORS

New Type. Stream-Line Filtration. Engineering (Lond.), vol. 128, no. 3324, Sept. 27, 1929, pp. 421–422, 3 figs. Description of filtering plant exhibited at Shipping, Engineering, and Machinery Exhibition at Olympia; new type of apparatus specially designed for renovating lubricating oil from small plants, such as small Diesel engines, or that from small fleets of motor-transport vehicles; this type will deal with about a pint of lubricating oil per hour.

OPEN-HEARTH FURNACES

Design. Recent Experiences With Maerz Type of Open-Hearth Furnace (Neuere Erfahrungen mit Siemens-Martin-Oefen, Bauart Maerz), E. Killing. Stahl und Eisen (Duesseldorf), vol. 49, no. 31, Aug. 1, 1929, pp. 1121–1129 and (discussion) 1130–1132, 20 figs. Account of operating conditions and design development of Maerz heads in Julienhuette steel works; results of investigations of latest type of Maerz furnace; smelting results; heat balance; advantages and disadvantages of Maerz type.

P

PIPE, CAST IRON

Centrifugal Casting. Casts Long Pipe Centrifugally, E. Franchi. Foundry, vol. 57, no. 17, Sept. 1, 1929, pp. 757–760, 13 figs. Description of Franchi-Gregorini system of casting iron pipes centrifugally which was perfected in Brescia, Italy; building and equipment are described and process outlined; comparison of microstructure of this type of pipe with that of sand cast specimen.

PLANERS

Metal-Working. New Machine Cuts Time from Weeks to Days. Machy. (N. Y.), vol. 36, no. 7, Oct. 1929, pp. 120M–120N, 3 figs. Description of special-type machine built by William Sellers and Co., primarily for handling centrifugal pump casings of 6, 7, or 8 stages; four distinct kinds of operations including milling, boring, facing, and grinding are performed in one set-up of work; machine is equipped with rail milling head, right-hand side milling head, grinding head on rail and boring head which is carried on extended apron that is integral with left-hand end of rail; pump casings simplified from 28 to two parts.

Tandem. The Butler Tandem Planing Machine. Brit. Machine Tool Eng. (Lond.), vol. 5, no. 57, May-June 1929, pp. 233–234, 2 figs. Description of tandem-type planer constructed by Butler Machine Tool Co., Halifax, for rapid machining of copper ingots; 16-ft. table of this machine is divided into 8-ft. lengths with facility for operating in one length of 16 ft. if desired.

PLASTICS

Erinoid. Erinoid, Its Properties and Machining Qualities. Machy. (Lond.), vol. 34, no. 883, Sept. 12, 1929, p. 755. Physical and electrical

properties of Erinoid; results of tests made at National Physical Laboratory to ascertain effect of soaking Erinoid in various liquids for two weeks; material may be readily turned, sawn, drilled, glued, and dyed; high-speed tools recommended for machining; Erinoid cannot by any means be made fully plastic.

PLATES

Stresses in. Stresses and Deflections in Flat Circular Plates With Central Holes, A. M. Wahl and G. Lobo. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 13 pp., 21 figs. Simplified formulas are derived for calculating maximum stress and maximum deflection of flat circular plates having central holes; eight different loading and edge conditions are considered; these formulas are presented in usable form for practical designer; approximate solutions are given for purpose of checking formulas; experimental determinations of stress and deflection for certain cases indicate that formulas are sufficiently accurate for practical work where edge conditions are determinate.

PLYWOOD

Use in Woodwork. Plywood Cores as a Foundation for Good Woodwork, E. V. Knight and T. D. Perry. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 16–18, 7 pp., 7 figs. Plywood consists of laminated sheets of wood; core supports interlocking layers and face veneer; various manufacturing problems of plywood are discussed in this paper; various woods used are selected for their strength, artistic figure, and wood work ability; some physical characteristics of more usual species of wood are given; various types of joints and methods of matching and glueing are described, and department layouts for two plants are given to illustrate routing procedure and types of woodworking tools used.

POWER COSTS

Distribution of. The Distribution of Power Costs, J. J. Berliner. Blast Furnace and Steel Plant, vol. 17, no. 9, Sept. 1929, pp. 1376–1378. Several methods for apportioning costs in distribution of power are mentioned and their fitness under different conditions is explained; examples given of part that power assumes in conversion cost of manufacture in one factory; distribution by estimated percentages; unit cost or cost constant method; distribution of power costs by metered amounts.

POWER GENERATION

Polar Seas. Natural Energy Which Can Be Utilized (Une energie naturelle utilisable), H. Barjot. Académie des Sciences—Comptes Rendus (Paris), vol. 187, no. 23, Dec. 1928, pp. 1048–1050. See also translation in World Power (Lond.), vol. 12, no. 69, Sept. 1929, pp. 217–220, 5 figs. Barjot process is based on capacity of large natural bodies of water to retain and store up during winter large amounts of heat; by causing one cubic meter of water to freeze as much energy may be given out as that contained in 22 lb. of coal; description is given of method of energy extraction, details of generating plant, and of advantages claimed for process.

PRESSES

Drawing. Large German Drawing Presses. Engineer (Lond.), vol. 148, no. 3842, Aug. 30, 1929, p. 233, 4 figs. partly on p. 232. Press described is largest of series of five of type designed for all kinds of drawing, deep stamping and forming operations as required in manufacture of motor-car body work, fenders, oil pans, radiator casings, metal furniture; width between frames 63 in., maximum depth of draw 11.8 in., area of table 63 in. by 47.2 in., stroke of blank holder 15.7 in., drawing pressure, approximately 125 tons, finishing pressure, approximately 160 tons, strokes per minute eight, thickness of bolster plate 5.2-in., and weight of machine 43 tons.

PRESSURE VESSELS

Non-Ferrous Metal. Use of Non-Ferrous Metals in Construction of Pressure Vessels (Verwendung von Nichteisenmetallen im Dampffassbau), Scheffel. Waerme (Berlin), vol. 52, no. 30, July 27, 1929, pp. 581–584. Use of copper, aluminum, nickel, and stainless steels in construction of chemical apparatus is discussed; incorporation of these materials in new German pressure-vessel code now being formulated.

Testing. Fatigue Tests on Drums and Shells, H. F. Moore and T. M. Jasper. Iron Age, vol. 124, no. 13, Sept. 26, 1929, p. 853, 2 figs. Discussion of three points brought out by Babcock and Wilcox tests on full-size boiler drums reported by H. F. Moore in Sept. 5 issue of magazine; changes in design resulting from tests made by A. O. Smith Corp. to show seriousness of out of roundness, of wrong shape of heads, and of lack of reinforcing of openings.

PUMPING STATIONS

Diesel. Facts and Figures on Diesel Pumping Equipment, A. D. Couch. Oil Engine Power, vol. 7, no. 10, Oct. 1929, pp. 560–562 and 567, 3 figs. Extracts of paper delivered by author; general introductory discussion of Diesel engines and specific reference to operating cost data and comparisons with steam and electric pumping power based on results obtained in New Rochelle Water Co., Pocantico Hills, N. Y.; installation contains 338-hp. McIntosh and Seymour Diesel driving centrifugal pumps and generator through De Laval step-up gear.

England. New Pumping Station for the Mid-Kent Water Co. Water and Water Eng. (Lond.), vol. 31, no. 369, Sept. 20, 1929, pp. 397–399, 6 figs. Description and details of equipment of pumping station for district having population of 120,000 and area of 455 sq. mi.; plant consists of five 3-cylinder 165-b.hp. Mirrlees-Diesel engines coupled to six borehole and surface pumps 6 in. to 10 in. in diam. with heads from 207 ft. to 600 ft.; details of engines and pumps and their operation.

PUMPS

Leakage. On the Leakage of Water Through Clearance Space, S. Suzuki. Tokyo Imperial Univ.—Jl. (Tokyo), vol. 18, no. 2, July 1929, pp. 73–98, 5 figs. Account of experiments conducted to determine amount of leakage water through clearance spaces; apparatus used consisted of water way between two parallel planes with circular center inlet and boundary outlet.

PUNCH PRESSES

Lubrication. Large Presses Are Equipped for Centralized Lubrication. Iron Trade Rev., vol. 85, no. 14, Oct. 3, 1929, pp. 843–845 and 852, 10 figs. Description of lubrication system developed by Lubrication Devices, Inc., Battle Creek, Mich.; automatic valve used to supply each bearing with predetermined measured quantity of oil or grease at high pressure; example of installation in new press shop of Murray Corp. of America, Detroit, which is employed on 207 units having between 5200 and 5500 bearings; compressor may be hand or automatically operated; other installations described.

Zig-Zag. Fledermaus Zig-Zag Presses. Machy. (Lond.), vol. 34, no. 882, Sept. 5, 1929, pp. 730–733, 7 figs. Description of Zig-Zag presses built by Fledermaus A.G., Erfurt, for quantity production of blanks, punched, coined, or deep drawn from metal sheets or strips; diagram shows divisions of sheets to obtain best possible utilization of material; feed-gear mechanism consists of double indexing system which is enclosed within housing and derives its drive through universal-joint shaft for reciprocation of press ram.

R

RAIL MOTOR CARS

Gasoline-Electric. Hall-Scott 350-Hp. Gasoline Engines. Ry. Age, vol. 87, no. 13, Sept. 28, 1929, pp. 737–738, 2 figs. Description of engines used in recent Brill Gas-Electric Rail Cars designed for exceptional efficiency and incorporate numerous special features; designed notable for power and light weight; six cylinders have 7½-in. bore and 9 in. stroke with piston displacement of 2385.6 cu. in.; engine develops more than 350 hp. at 1100 r.p.m.; multiple ignition is supplied from two high-tension magnetos driven from valve shaft through helical gear by main accessory drive shaft.

Oil-Electric. Pennsylvania Installs Two Oil-Electric Rail Cars, D. C. Hershberger. Ry. Elec. Engr., vol. 20, no. 9, Sept. 1929, pp. 285–288, 5 figs. Cars are arranged for double-end control; auxiliaries receives power from both main generator and exciter; description of interior arrangement; oil engines; main and auxiliary generators; table gives principal weights and dimensions; control equipment; water and oil-cooling systems.

RAILWAYS

Monorail. The Railplane System of Transport, G. Bennie. Engineer (Lond.), vol. 148, no. 3841, Aug. 23, 1929, p. 206, 2 figs. Proposed system of transport is being investigated by London and Northeastern Railway Co. on full scale test track 426 ft. long; car is light, rigid construction supported by two laminated spring trucks running on suspended rail; car is driven by propellers operated either electrically or by internal combustion.

Signals and Signaling. Boston and Maine Uses Reverse-Traffic Signaling in Hoosac Tunnel, E. N. Fox. Ry. Age, vol. 87, no. 13, Sept. 28, 1929, pp. 711–713, 4 figs. Description of extensive rearrangement of signals and interlockers installed on double track line through Hoosac tunnel; line through tunnel is 5-mi. long; train movements directed from one point; automatic train stop.

Train Control, Automatic. Automatic Train Control, G. E. Ellis. Railroads (A.S.M.E. Trans.), vol. 51, no. 17, May-Aug. 1929, pp. 93–99, 8 figs. Brief review of early work done in automatic train control; government activities regarding their installation and requirements specified by Interstate Commerce Commission; classification of types of devices proposed, followed by brief description of each type; elements necessary for operation of all devices for automatic control; question of cost. See Engineering Index, 1928, p. 1555.

REFRIGERANTS

Carbon Dioxide. Refrigerating Characteristics of Carbon Dioxide, W. R. Woolrich. Power Plant Eng., vol. 33, no. 18, Sept. 15, 1929, pp. 1021–1024, 1 fig. Discussion of most important advantages of carbon dioxide when used as refrigerant; physical properties of carbon dioxide; characteristics of carbon dioxide in solid form; diagram of carbon-dioxide properties with standard ton cycle for carbon dioxide in outline; carbon dioxide in refrigerator car operation.

REFRIGERATING MACHINES

Carbon Dioxide. Mass Circulation in Carbon Dioxide Refrigerating Machines, H. Mawson. Instn. Mech. Engrs.—Jl. (Lond.), no. 2, Mar. 1929, pp. 389–421–432, 17 figs. Volumetric efficiency and clearance; refrigeration per unit effective compressor volume; liquid cooling; cycles in which two regulators are employed; representation of compound compression cycle on total-heat entropy chart; effects of incomplete separation of liquid from vapor in receiver.

REFRIGERATION

Automatic. New Type of Automatic Refrigeration. Ice and Refrig., vol. 77, no. 3, Sept. 1929, pp. 143–145, 5 figs. Description of highly improved system recently installed in Harvard Laboratory; embodies many features not found in other types; holds room at constant temperature, maintains definite temperature when power is off, operates with minimum use of electric current, and holds constant humidity; illustration of charts taken from recorders.

Multi-Pressure Systems. Power Costs Lowered by Multiple-Effect Compression, F. P. MacNeil. Power, vol. 70, no. 12, Sept. 17, 1929, pp. 446–447, 2 figs. Efficient performance of plant of East Shore Ice Co. at New Dorp, Staten Island, N. Y. C., has been accomplished with aid of compound multiple-effect compression; plant has produced first-quality ice at power consumption of 39.6 kw-hr. per ton using condenser and can water at 70 deg. fahr.; general description of plant with diagrammatic layout of engine room.

RIVETED JOINTS

Testing. Riveted Joints in Tension (Nietverbindungen mit Zugbeanspruchung), V. Bradel. Bauingenieur (Berlin), vol. 10, no. 27, July 1929, pp. 473–478, 3 figs. Theoretical, mathematical discussion of tension in riveted joints, induced by thermal or statical stresses; working stresses for riveted joints under constant or variable tensile stresses, with special reference to C. R. Young's tests.

ROLLING MILLS

Aluminum. Lighter Structures, R. L. Streeter. Eng. News-Rec., vol. 103, no. 14, Oct. 3, 1929, pp. 535–537, 4 figs. See editorial comment on p. 519. General layout of Aluminum Company's structural mill at Massena, N. Y., where aluminum shapes as large as 141 in. deep and 85 ft. long will be fabricated; plan of blooming mill at Massena, N. Y.; mill crane 72 ft. span and 10-ton capacity built of aluminum alloy.

American vs. European. European and American Mills Compared, A. Noell. Blast Furnace and Steel Plant, vol. 17, no. 9, Sept. 1929, pp. 1339–1343, 11 figs. Practices in American and European rolling mills are compared and new machines are described; combine blooming, beam, and rail mills in Europe; special rolling-mill features used in combination with merchant mills; capacity of merchant mills increased by rolling in multiples smaller size rods, using one hot-bed; machine for handling flats; new straightening machine.

Efficiency. Efficiency and Power Consumption in Rolling Mills (Leistung und Kraftverbrauch im Walzwerk), H. Schreyer. Archiv. fuer das Eisenhuettenwesen (Duesseldorf), vol. 3, no. 2, Aug. 1929, pp. 117–122, 9 figs. See

also Stahl und Eisen (Duesseldorf), vol. 49, no. 36, Sept. 5, 1929, pp. 1312–1313, 3 figs. Results of investigations carried out on large and medium-section three-high mills at Peine to determine efficiency and power requirement in rolling mills; determination of increase in load in rolling of single ingots and in simultaneous rolling of several ingots; influence of design of rolls, temperature, and chemical composition of materials on increased load.

Forming Mill, New Type of. New Metal Forming Mill. Iron Age, vol. 124, no. 13, Sept. 26, 1929, p. 842, 2 figs. Description of new type of forming mill brought out by Farrel-Birmingham Co., Buffalo; each stand is individual unit, and is driven through bevel gears in cast-iron housing, gears receiving power from single back-shaft driven by one motor; individual stand houses spindle bearings, connecting gears and mechanism for adjusting roll centers; method of adjusting top roll spindle.

Strip Mills. Semi-Continuous Mill for Rolling of Strip Iron (Halbkontinuierliches Walzwerk fuer Bandeisen), E. Immerschitt. V.D.I. Zeit. (Berlin), vol. 73, no. 38, Sept. 21, 1929, pp. 1333–1338, 19 figs. Details of mill equipment of August Thyssen plant at Dinslaken built by Demag A.G., for Vereiningte Stahlwerke, A.G., to produce strip iron 100 to 450 mm. in width and 1.25 to 3.0 mm. in thickness.

S

SEAPLANES

Design. A.S.M.E. Seaplane Meeting at Cleveland, E. P. Warner. Aviation, vol. 27, no. 11, Sept. 14, 1929, pp. 571–573. Review of Aeronautical meeting of American Society of Mechanical Engineers in Cleveland with abstracts of papers presented; uses of seaplanes and conditions governing their design and construction, T. P. Wright and G. A. Luburg; possibilities in use of hydrovanes or separate planing surfaces below hull of seaplane; problem of design treated by A. Rohrbach with more technical detail; advantages of amphibian gear for commercial use; catapulting aircraft, W. M. Fellers; float design, H. C. Richardson.

Racing. The British Schneider Trophy Defenders. Flight (Lond.), vol. 21, no. 34, Aug. 22, 1929, pp. 889–891, 3 figs. Description of Gloster VI low-wing seaplane to take part in Schneider Trophy Race; Napier VII D racing engine; comparison with Rolls Royce powered Supermarine S-6 seaplane; monocoque fuselage and floats of Gloster VI built of duralumin; wings of wood; control surfaces geared down in relation to stick and foot bar for small initial movements and geared up for large movements; unusual features of engine water and oil cooling systems; fuel carried in floats.

SMOKE RECORDERS

Photoelectric. Photo-Electric Smoke Recorders V. P. Griffin and J. V. Breisky. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. Oct. 7–10, 1929, 7 pp., 14 figs. Paper discusses necessity of measuring smoke density in stacks of power plants, so as to enable operator to keep smoke down to minimum; methods of smoke determination that have been available in past are described; necessity of continuous and permanent record is brought out, feature which has not been available in apparatus heretofore in use; photo-electric smoke recorder is described; scheme of operation is to project beam of light through stack or breeching on photo-electric cell.

SOUND

Measurement of. A Measurement of the Sound Pressures on an Obstacle, W. West. Instn. of Elec. Engrs.—Jl. (Lond.), vol. 67, no. 393, Sept. 1929, pp. 1137–1142, 6 figs. Subjects dealt with investigation of performances of small condenser transmitter under different conditions of test is described; results are reduced to terms of augmentation of sound pressures at surface of transmitter, considered as obstacle in sound field; and comparison is made with calculated pressures developed on spherical obstacle.

SPRINGS

Conical, Design of. Conical Spring Design—Some New Facts and Formulas, J. K. Wood. Am. Mach., vol. 71, no. 15, Oct. 10, 1929, pp. 620–624, 8 figs. Results of research that alter some of basic formulas heretofore used in this branch of design are discussed; new deflection formula for conical springs which takes into account vertical shear and deflection multiplication factor; new formulas are given for design of round-wire conical springs.

STEAM

Pressure Transformers. Pressure Transformers, an Innovation in the Field of Heat Engineering (Der Dampfdruckumwandler, eine Neuerung auf dem Gebiet der Waermetechnik), J. Hausen. Chemische Apparatur (Leipzig), vol. 16, no. 7, Apr. 1929, pp. 69–71, 1 fig. Details of process and equipment developed by E. Koenemann, according to which cycle is performed by binary mixture; fundamental principle of process is based on absorption which steam over any liquid undergoes when heat is withdrawn; process is employed for raising pressure of exhaust steam. See reference to description by L. S. Marks in Engineering Index, 1927, p. 338.

Supersaturation. Supersaturation in Steam and Its Influence Upon Some Problems of Steam Engineering, C. F. Powell. Engineering (Lond.) vol. 127, nos. 3308 and 3309, June 7 and 21, 1929, pp. 711–713 and 779–780, 6 figs.; see also editorial comment, pp. 791–792. Account of experiments to determine value of limiting supersaturation at different temperatures; from results, true position of "Wilson line" can be fixed; it corresponds closely with ordinary line of 2 per cent wetness at low pressures; applied to calculation of heat drop for supersaturated expansions.

STEAM ENGINES

Traction-Type. Modern Boiler-Engine Units (Neuzeitliche Heizkraftlokomobilen), K. Heilmann. Waerme (Berlin), vol. 52, no. 35, Aug. 31, 1929, pp. 687–690, 6 figs. Modern development of combined boiler-engine units is characterized by improvements in design and operation, such as application of pressure lubrication for large machines and by adaptation to requirements of combined power and heat supply; some noteworthy installations for power and heating supply are described.

STEAM-ELECTRIC POWER PLANTS

Pulverized-Coal-Burning. Growth of Pulverized Coal Combustion, F. A. Scheffler. Elec. World, vol. 94, no. 7, Aug. 17, 1929, p. 326. Growth since 1926 shows increase from 37 to 64 plants representing 2,179,000 and 3,275,500 kw. installed capacity; plants now under construction will put more than 4,000,000 kw. on pulverized coal basis; table showing public utility plants in United States operated with pulverized coal.

Trinidad, Tex. Texas Plant Burns Lignite, E. T. Keck. Coal Age, vol. 34, no. 7, July 1929, p. 429. Plant of Texas Power and Light Co.; pulverized lignite proves economical; boilers are 18,756-sq. ft. Babcock and Wilcox type with interdeck superheaters for steam pressure of 425-lb. gage; main turbines are 20,000-kw., 14-stage, 1800-r.p.m., single-cylinder. General Electric units for steam pressure and temperature of 375-lb. gage and 700 deg. Abstract from Elec. World as in Eng. Index, 1928, p. 1746.

STEAM POWER PLANTS

Germany. Large Thermal Power Stations in Germany (Les Grandes Centrales Thermiques Allemandes), P. Jarrier. Technique Moderne (Paris), vol. 21, no. 15, Aug. 1, 1929, pp. 469–472, 8 figs. Review of tendencies in equipment of boiler houses; vertical water-tube type is most in favor; there has been reaction in favor of moderate pressures; advantages of high pressures are undubitable but limited; chain grates are used on about half boilers; boom in pulverized-coal firing was not maintained in 1927, owing to progress in various types of grates and extensive adoption of lignite; use of automatic control for feedwater, fuel supply, and combustion is steadily extending.

1500 Lb. Pressure Steam Plant at Mannheim Power Station, F. Marguerre. Engineering (Lond.), vol. 128, no. 3322, Sept. 13, 1929, pp. 313–315, 5 figs. Problems in design of feed pumps because of high pressure; oil pumps are variable-speed type, two driven by steam turbines and two by motors; turbines are designed for admission pressures of 1425 lb. per sq. in. and exhaust pressure of 285 lb. per sq. in.

Industrial, Costs of. High Pressure Industrial Power Plant Costs, J. F Ferguson. Power Plant Eng., vol. 33, no. 18, Sept. 15, 1929, pp. 989–991, 2 figs. In 1800-lb., 9000-kw. high back pressure development it was found that entire plant could be completed for less than $100 per kw. of capacity; curves showing comparative cost of complete steam-electric plants for different design, also curves of comparative cost of single-unit complete steam-electric plant for full pressure range.

STEEL

Chromium. See CHROMIUM STEEL.

Manufacture—Basic vs. Acid Process. Comparative Evaluation of Basic and Acid Steel Melting Furances (Wie ist der basische Stahlschmelzofen gegenueber dem sauer zugestellten zu bewerten), E. Piwowarsky. Giesserei (Duesseldorf), vol. 16, no. 31, Aug. 2, 1929, pp 685–693, 9 figs. Constitution of basic and acid furnace slags is discussed; basic slag is dissociated to marked degree with free oxides of iron and manganese; acid slags are only slightly dissociated with oxides; significance for processes of dephosphorization, desulphurization, and deoxidation; acid and basic steel from viewpoint of quality.

Nickel. See NICKEL STEEL.

Quenching. Hot Aqueous Solutions for the Quenching of Steels, H. J. French and T. E Hamill. U. S. Bur. of Standards—Jl. of Research, vol. 3, no. 3, Sept. 1929, pp. 399–418, 14 figs. Surface and center cooling curves are given for small cylinders of high-carbon steel quenched in water, sodium hydroxide, sodium-chloride solutions, and oils at different temperatures; characteristics of these cooling curves and study of hardness and structures produced suggested possibility of using some hot aqueous solutions to bring gap between cooling rates obtained with water and oils at atmospheric temperatures.

Stainless, Welding. Welding of Stainless Materials, H. Bull and L. Johnson. Nat. Advisory Committee for Aeronautics—Tech. Memo. No. 532, Sept. 1929, pp. 1–26 and (discussion) 26–37, 30 figs. on supp. plates. Properties of various stainless steels are considered with reference to methods of welding them, stainless steels used in manufacture of turbine blades and cutlery; reasons why stainless steels would be benefitted by heat treating; welding Twoscore steel used in seaplane industry; austenitic steels; conditions for welding; outline of electric-resistance, arc, and oxyacetylene welding. From Industrial Gases, March and June, 1928.

T

TESTING MACHINES

Compression. 200 Ton Hydraulic Compression-Testing Machine, F. C. Turner. Engineering (Lond.), vol. 128, no. 3322, Sept. 13, 1929, pp. 322–323, 8 figs. Machine described was designed by author to meet need of Materials Testing Laboratory of Univ. of Sheffield for large capacity machine for compression tests on concrete, brick, stone, wood props, and beam tests; oil pressure acting on piston both loads test piece and also takes up resulting strain; design calibrations are given and methods of calibrating machine are explained.

THERMODYNAMICS

Principles. Thermodynamic Principles (Thermodynamique), C. Raveau. Académie des Sciences—Comptes Rendus (Paris), vol. 188, no. 26, June 24, 1929, pp. 1662–1665. Criticism of the fundamental principles of thermodynamic theory with special reference to the conception of entropy, Le Chatelier's principle and relation between the Clausius and Clapeyron equations.

TURBO-COMPRESSORS

Calculation of. The Calculation of Turbo-Compressors. Information on Refrigeration—Bul. (Paris), no. 11, Mar. and Apr. 1929, pp. 3–52, 26 figs. Under design calculations of turbo-compressors following factors are considered: meaning of various values found, efficiencies and characteristic figures of elementary and multiple turbo-compressors, etc.; under application of turbo-compressors to refrigerating industry following factors are considered; influence of choice of refrigerant on units of compression, influence of refrigerant on dimensions of turbo-compressor, and on nature of compression and hence on intermediate cooling.

W

WIRE ROPE

Strength of. The Strength of Wire Ropes. Metallurgist (Supp. to Engineer, Lond.), Aug. 30, 1929, pp. 120–121. Review of tests by R. Woernle in which various types were compared in regard to their endurance under similar treatment, that is, on basis of number of times they would stand bending operation of specified type before failure; effects investigated were those of radius of pulley-groove, lay of rope, loading, diameter of wires, strength of material; measurements were made of elongation of ropes by usage, and data were obtained regarding reduction in carrying capacity of ropes to enable period of useful life to be judged from number of reversals of bending.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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What It's All About

BECAUSE a reader of MECHANICAL ENGINEERING asked for a summary of its contents so that he might know at a glance "what it's all about," the editors instituted this supplement to describe in simple language the principal articles of each issue. It is intended to be more than an extended table of contents. An effort is made to present the central idea of the month's contributions so that laymen as well as engineers can understand it. It is not intended to make a reading of the papers themselves unnecessary, but to whet the appetites of those who find subjects of interest to them.

In a small way, this supplement is an essay in interpretation. Because it is not bound into the magazine it lends itself to easy distribution. More people are interested in engineering than is generally known. Some friend may be interested in one of the items summarized. Why not pass the supplement on to him so that he, too, may know "what it's all about?"

Are Engineers Human?

ARE engineers persons of importance? This is a question which L. W. Wallace, executive secretary of the American Engineering Council, and J. E. Hannum, editor of the Engineering Index Service, asked themselves. With characteristic engineering directness, these two examined the facts by making a statistical study of the names listed in "Who's Who." They found that of the 28,805 listed, the group of scientists, including engineers, architects, physicians, and surgeons, numbers 8863, or 30.4 per cent. Of these, 2858, or nearly 10 per cent of the total, are engineers and architects. These men have received 2497 scientific degrees and 1417 academic degrees in branches of learning other than science. They hold 4785 official positions in 3928 organizations, of which 2993 are industrial and commercial.

The findings clearly show, say Messrs. Wallace and Hannum, "that engineers and architects are versatile, not narrow; internationally, not provincially minded; leaders, not followers; scholarly, not unlearned; cultured, not rude; lovers, not haters of mankind."

The results of this study are to be presented at the Annual Meeting of The American Society of Mechanical Engineers which takes place in New York during the first week of December. The paper in which the results are set forth and discussed is published in the December issue of MECHANICAL ENGINEERING.

Commercial Airplanes

AFTER all, an airplane is a means of transportation, and as such, Charles Talbot Porter, of the Keystone Aircraft Corporation, points out in a paper on "Factors in the Design of Commercial Airplanes" in the December issue of MECHANICAL ENGINEERING, it is of value only when the commodity thus supplied can be marketed at a lower price for service rendered than similar service offered by other methods. At present, he says, the airplane cannot compete either in price or in comfort with the extra-fare train; hence its principal reason for being is speed.

Mr. Porter advocates a 30- to 40-passenger airplane that will have a speed of 135 to 145 miles per hour with a reduction from the present 100 horsepower per passenger to a hoped-for 50 or 60 horsepower per passenger. To obtain this result he advocates abandoning direct-drive air-cooled radial engines and replacing them by geared engines, air or liquid cooled, placed preferably inside the wing, with a remote drive to the propellers. The airplane itself should approach the flying wing, the wing loading should be high, and the landing gear should be retractable. It should have large brakes operated by mechanical power. The material of construction will depend upon the depreciation factor.

The Navy's "Tin Bubble"

THIS year has been a good one for dirigibles. The successful circumnavigation of the world by the *Graf Zeppelin* has given the lighter-than-air ship almost as much publicity as the airplane got through Lindbergh's flight to Paris.

In August a new type of airship took the air. It was the "metalclad" 200,000-cu-ft. dirigible *ZMC-2* of the United States Navy, built at Detroit. This is a single-structure unit in which the surface plates carry a considerable portion of the direct stress. This surface is made of a lightweight metal, Alclad, less than one-hundredth of an inch thick, and is assembled over a rigid frame. It serves also as the helium-gas container. The 142 sheet-metal rings of the surface are sewed together by means of a special riveting machine which drives three rows of rivets along the seam simultaneously at the rate of 140 per minute.

The *ZMC-2* was delivered at Lakehurst, N. J., on September 12, and on September 19 it completed successfully its final test.

Carl B. Fritsche, president of the Aircraft Development Corporation, described this remarkable airship at the Third National Meeting of the A.S.M.E. Aeronautic Division, St. Louis, Mo., in May, 1929. An abridgment of the revised paper, brought up to September 20, is published in MECHANICAL ENGINEERING for December.

Hooke's Law

INVESTIGATION of nature's laws frequently reveals comparatively simple relationships that can be represented by simple mathematical expressions. Thus, for instance, Boyle's law, that the product of the pressure and volume of a gas is a constant if the temperature is

Second, the searcher may wish some simple and automatic way of keeping posted on a given subject, the metallurgy of iron and steel, for instance. A brief survey of every batch of cards received, or of this section of the book, performs this service.

Then there is that third individual who is looking for an idea, something that will apply to his problem. A maker of radio cabinets, for example, might discover from the reported experience of some one in a similar field that what his business needs is not more machinery but a more intelligently planned production method. An idea—a starting point for an active mind.

But an index is useless unless the original article can be located. Every reference published by the Engineering Index Service is in the United Engineering Societies Library in New York and can be found there if not elsewhere. A photostat and translation service makes the Library available to every one, no matter what may be the limitations of his location or his ability to read foreign languages.

MECHANICAL ENGINEERING selects every month approximately 200 references of interest to its readers. These are indicative of what may be found relating to all branches of engineering in the complete index.

The Arrow of Time

EDDINGTON performed an immense service to science when he hit upon the phrase "The arrow of time" as a connotation of entropy. Every student of thermodynamics who has wrestled with the semi-physical, semi-philosophical concept of entropy and has attempted to conceive of it as clearly as he visualized pressure or temperature, should read the British astronomer's chapter on this subject in his book "The Nature of the Physical World." He will turn from it with a sense of satisfaction and gratification, and then read the rest of the book.

Invention and Research

IN HIS address at Dearborn, Mich., on the occasion of Light's Golden Jubilee, President Hoover paid tribute to Thomas A. Edison as an inventor who used the powerful tool of research.

"In earlier times," said the President, "mechanical invention had been the infrequent and haphazard product of genius in the woodshed. But science had become too sophisticated a being to be wooed in such surroundings. Nowadays a thousand applied-science laboratories, supported by the industries of one country, yearly produce a host of new inventions."

"Research both in pure science and in its application to the arts is one of the most potent impulses to progress."

In the first Henry Robinson Towne lecture, delivered on Dec. 1, 1925, at the Annual Meeting of The American Society of Mechanical Engineers, President Hoover, then Secretary of Commerce, speaking on research, said:

"The day is gone by when we can depend very much on consequential discovery or invention being made by the genius in the garret. A host of men, great equipment, long, patient, scientific experiment to build up the structure of knowledge, not stone by stone but grain by grain, is today the fundamental source of invention and discovery."

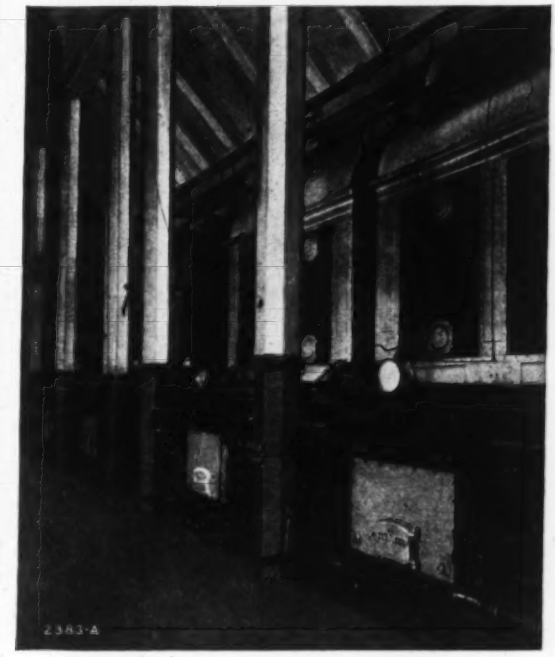
Research has paid handsomely in this country. It has increased our financial prosperity, it has extended our physical comfort and length of life, and it has added luster to our honor by developing great men. It is the process by which civilization advances, for it makes possible the bringing of light, not to a few, but to all.

Not Slaves of Machines

MICHAEL PUPIN, whose rise "from immigrant to inventor" is one of the epics of opportunity in this country of free institutions, delivered an address at the 175th anniversary of the granting of a charter to Columbia University in which he denied that American scientists and engineers have created a civilization that is a sordid materialism.

"The European critics of our civilization," he said, "accuse our scientists and engineers of worshipping the machine, the only product, they say, of their utilitarian American mind. If I had ever imagined that my distinguished pupils, Dunn, Millikan, Langmuir, Armstrong, and many others were slaves of a utilitarian mind lying prostrate in the presence of machines, I should have confessed long ago that my mission at Columbia was a complete failure. But I am far from such a confession."

The European philosophic mind which has analyzed so frequently our American civilization generally refuses to admit that man need not be, and generally is not, a slave to the machine any more than he has always been a slave to his environment. It is refreshing to have the dark aspect of this European viewpoint brightened by such words of faith and conviction as Dr. Pupin has uttered.



State Capitol Power and Heating Plant, Madison, Wisconsin

Four 400-hp. Stirling boilers are equipped with Elesco superheaters for the following conditions:

uperheat.....75 deg. F.
Pressure.....150 lb. per sq. in.
Rating.....200 per cent

"We are very well satisfied...

both with the equipment and the service given by The Superheater Company."

So wrote Mr. John C. White, State Power Plant Engineer in his report on Elesco superheaters at the Wisconsin State Capitol Power and Heating Plant.

Formerly this plant operated with saturated steam. Recently Elesco superheaters were installed in the boilers one at a time, as they could be spared. Superheated steam has plainly bettered the performance of the four Corliss engine driven units, and resulted in other economies.

The simple, compact design and the ideal accessibility of Elesco superheaters adapt them to economical installation in existing boilers.

Investigate their many advantages.

THE SUPERHEATER COMPANY

Peoples Gas Bldg. CHICAGO — **17 East 42nd Street, New York** — Union Trust Bldg. PITTSBURGH

ELESCO

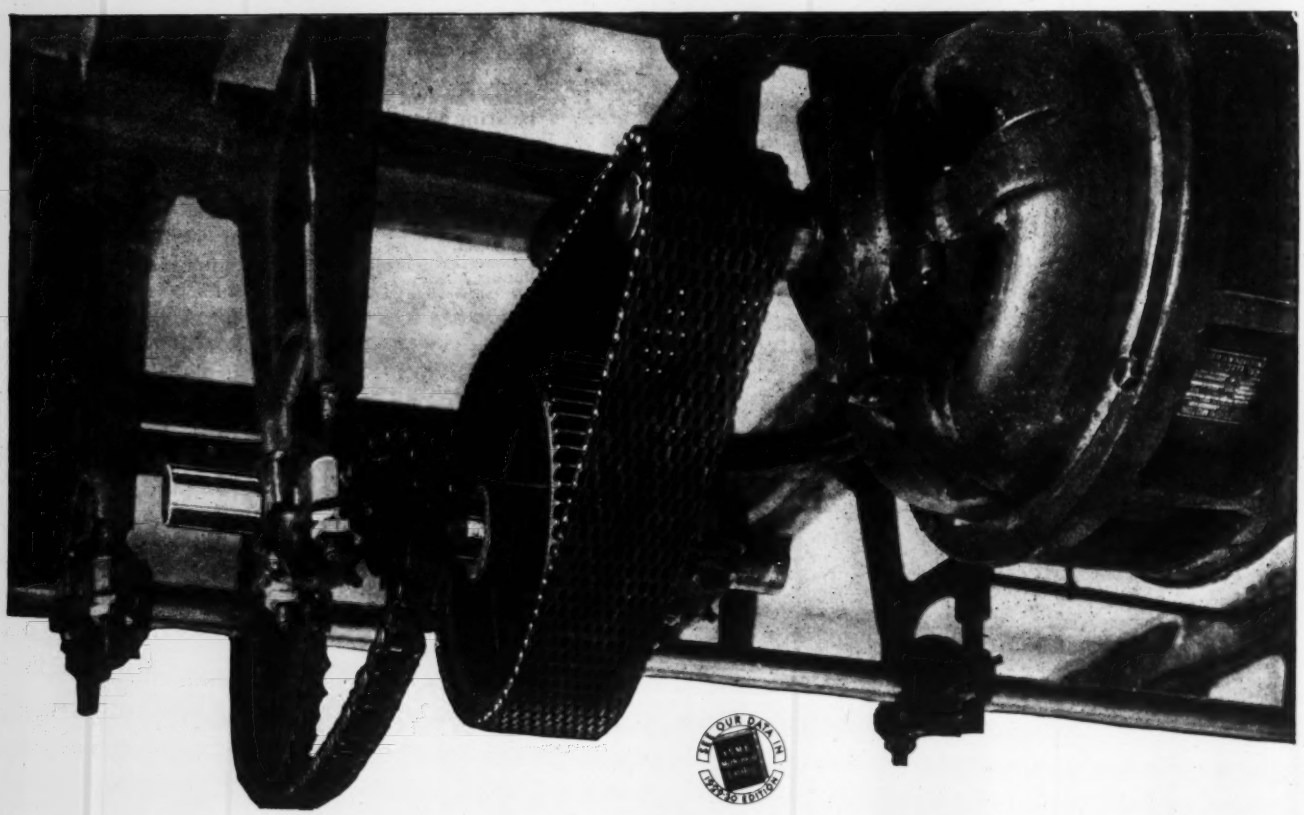
CANADA: The Superheater Company, Limited, Montreal

Represented in

Atlanta Charlotte Denver New Orleans Houston San Francisco Kansas City Memphis

LET OUR DATA IN MAKE TO EDITION

A-266



Economical Plant Operation

depends on efficient transmission of Power

The two WHITNEY Chain Drives pictured here on line-shafting show how WHITNEY Chains of different types should be selected for different requirements to insure maximum efficiency and economy.

For the high-speed drive from motor to countershaft, WHITNEY Silent Chain gives the necessary smoothness to insure quiet, efficient service.

For the slower-speed drive from countershaft to main line shaft a WHITNEY Roller Chain at lower cost gives equally satisfactory service.

WHITNEY engineers will be glad to advise regarding the proper choice.

The Whitney Manufacturing Co.
Hartford, Conn.

SALES AND ENGINEERING OFFICES

NEW YORK
L. C. Biglow & Co., Inc.
250 W. 54th St.
BOSTON
The Whitney Mfg. Co.
250 Stuart St.
PHILADELPHIA
The Whitney Mfg. Co.
133 So. 36th St.
Philadelphia Gear Works
Erie Ave. and G St.
SYRACUSE
George McPherson
201 Norwood Ave.
CHICAGO
The Whitney Mfg. Co.
549 W. Washington Blvd.
PITTSBURGH
Pittsburgh
Gear & Mach. Co.
27th & Smallman Sts.
CLEVELAND
Smith Power
Transmission Co.
1213 W. Third St.
DETROIT
The Whitney Mfg. Co.
2-240
General Motors Bldg.
SAN FRANCISCO
A. H. Coates Co.
615 Howard St.
SEATTLE
A. H. Coates Co.
1743 First Ave. So.
LOS ANGELES
A. H. Coates Co.
2011 Santa Fe Ave.
PORTLAND, ORE.
Portland Iron Works
495 Northrup St.

WHITNEY CHAIN DRIVES

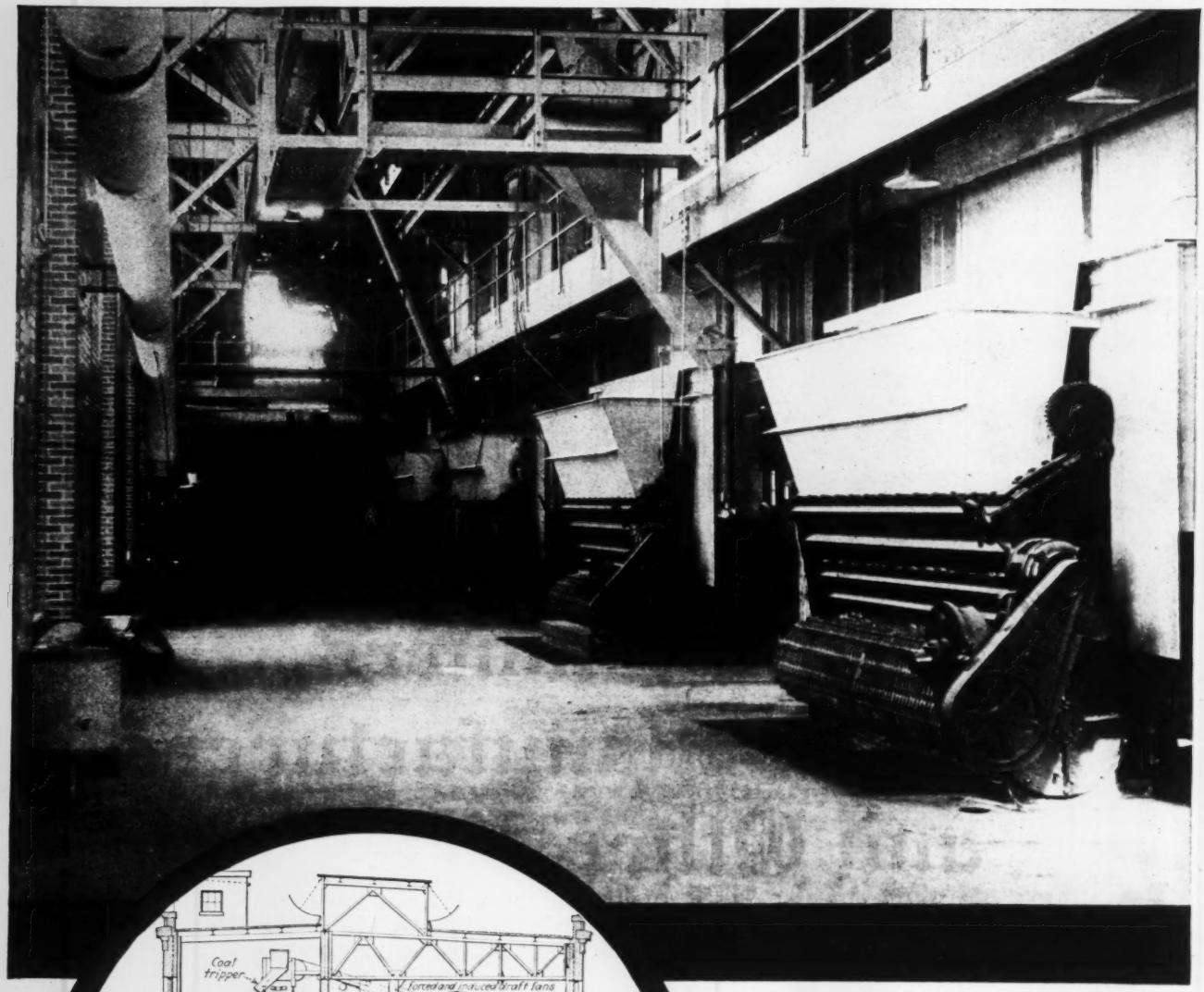
To Customers, Fellow Manufacturers and Other Friends

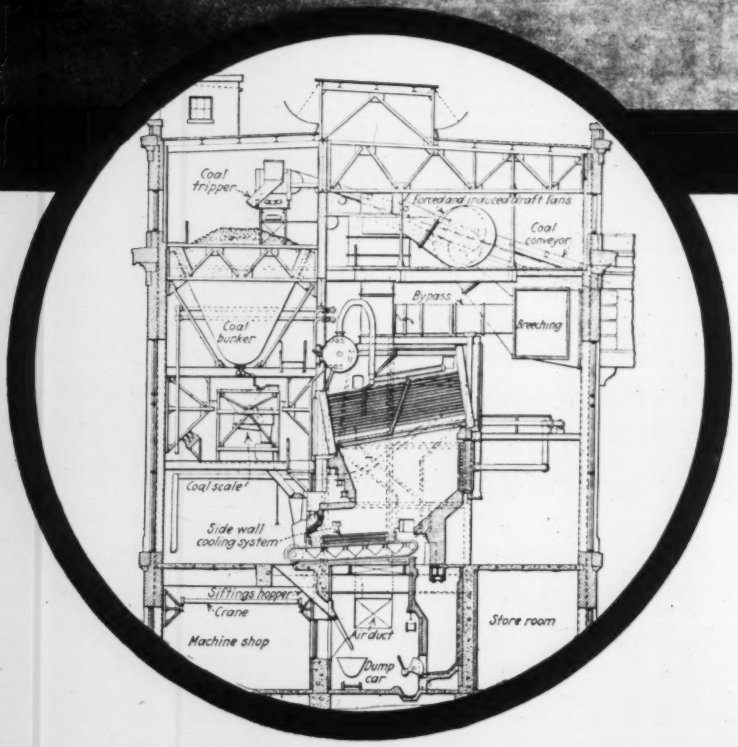
At this season of rejoicing and festivity, we are only too happy to pause for a moment in our appointed task of designing, manufacturing and selling the world's greatest line of control specialties, to wish our legion of customers, fellow manufacturers and our host of friends

A Most Merry Christmas and Prosperous New Year

FISHER

THE FISHER GOVERNOR COMPANY, Inc.
MARSHALLTOWN, IOWA





Cross section through the Howard Bend Pumping Station showing the arrangement of C-E Boiler (Heine cross drum Type) and C-E Stoker (Green Forced Draft Type). All four units are similarly arranged.

COMBUSTION

DISTINCTIVE INSTALLATIONS of C-E Equipment

The Howard Bend Pumping Station, St. Louis, is one of the latest and most modern pumping stations in America and is representative of the changing trend toward improved steam plant operation.

The boiler room was specially designed to assure reliability and flexibility. C-E Boilers (Heine cross drum Type) and C-E Stokers (Green Forced Draft Type) were chosen.

The steam pressure is higher than that normally used in water works, the boiler being operated at 325 lb. pressure and superheat of 245 deg. fahr. giving a final steam temperature of approximately 670 deg. Another departure from ordinary water works practice is drawing CO_2 from the boiler flue gas to charge the water in the process of purification.

• • •

COMBUSTION ENGINEERING CORPORATION

International Combustion Building . 200 Madison Avenue, New York, N. Y.

A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

ENGINEERING

AIR PREHEATING

Can you afford to use other than a

REGENERATIVE PREHEATER

THE Ljungström Regenerative Preheater gives the highest recovery obtainable, weighs less than one-half and occupies less than one-third of the space of any other type preheater of equal recovery.

The cost of the Ljungström Preheater is lower—for very high recovery, much lower than that of any other preheating equipment.

The saving in building space and cost, in cost of foundations and duct work contribute to placing the investment return from the Ljungström Preheater on a plane which is approached by no other.

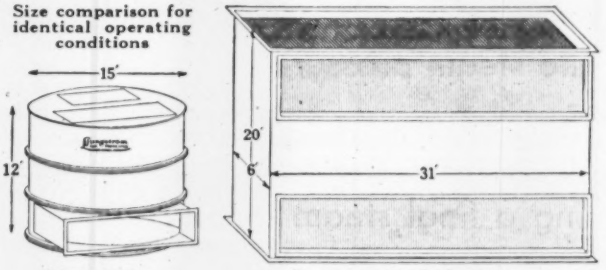
These facts are recognized following close investigation. Those mentioned at the left are only part of the list of purchasers of Ljungström Preheaters within the past six months.

Some recent purchasers of LJUNGSTRÖM PREHEATERS

*** = Repeat Orders**

East New Jersey Power Co., Sayreville, N. J.	4 Preheaters
Indianapolis Lt. & Pr. Co., Indianapolis, Ind.	8 Preheaters
Buffalo Genl. Electric Co., Buffalo, N. Y.	6 Preheaters
Iowa-Nebraska Lt. & Pr. Co., Lincoln, Neb.	2 Preheaters
*Iowa Railway & Lt. Co., Cedar Rapids, Iowa.	4 Preheaters
Georgia Power Co., Atkinson, Ga.	2 Preheaters
*Phoenix Utility Co., Dallas, Tex.	2 Preheaters
*N. W. Public Service Corp. Mitchell, S. D.	2 Preheaters
*Sinclair Refining Co., East Chicago, Ind. and Coffeyville, Kans.	2 Preheaters 1 Preheater
*West Virginia Pulp and Paper Co., Tyrone, Pa.	2 Preheaters
*United Sugar Companies, Los Mochis, Mex.	1 Preheater
Philadelphia & Reading C. & I. Co., Locust, Pa., (Stone & Webster Eng. Corp.) Engineers	2 Preheaters
*Standard Oil Co. of Indiana, Casper, Wyo.	1 Preheater

People like these would not choose LJUNGSTRÖM PREHEATERS unless there were good reasons



Ljungström. Wt., 110,000 lb. Volume, 2100 cu. ft.

Recuperative Preheater. Wt., 220,000 lb. Volume, 3720 cu. ft.

Let us submit convincing performance data and references to time-tried installations where all guarantees have been well met.

Over 800,000 boiler hp. in service in the U.S.A.

THE AIR PREHEATER CORPORATION
40 E. 34th St., New York

Works: Wellsville, New York, Agents in

Boston	Charlotte	Cleveland	St. Louis	Pittsburgh	Houston
Buffalo	Denver	Philadelphia	New Orleans	Cincinnati	Los Angeles
Chicago	Detroit	Minneapolis	San Francisco	Kansas City	Tacoma

Canada: Lammers & Maase, Ltd. Montreal and Vancouver

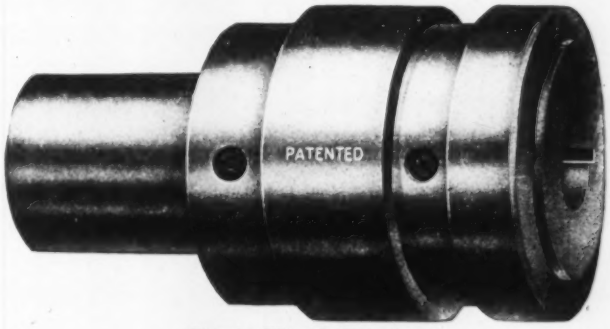
Ljungström AIR PREHEATER
Reg. U.S. Pat. Off.
CONTINUOUS REGENERATIVE COUNTERFLOW

THE JOHNSON FRICTION CLUTCH

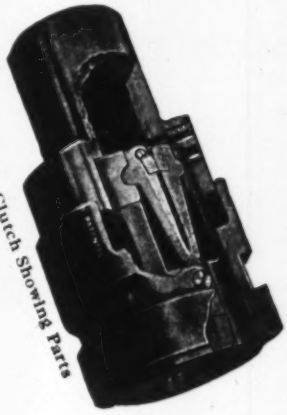
ALL

MECHANICAL ENGINEERS

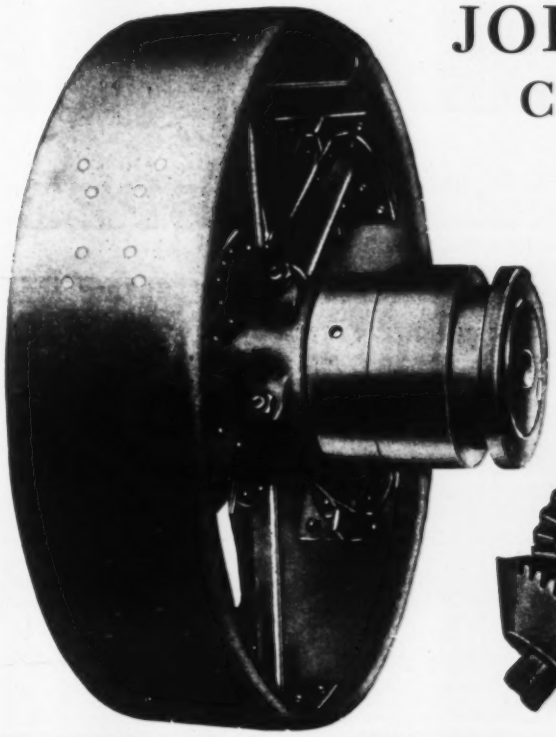
Should Become Acquainted with THE JOHNSON FRICTION CLUTCH That Lasts 15 to 20 YEARS



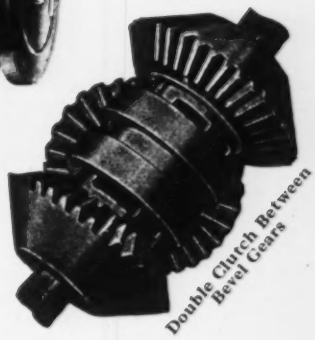
Single Clutch Exterior



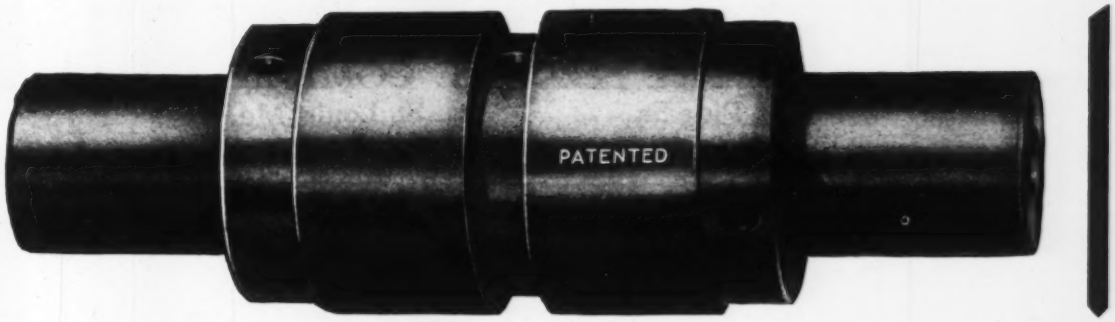
Single Clutch Showing Parts



Single Clutch Mounted with Steel Split Pulley



Double Clutch Between Bevel Gears



JOHNSON Double Clutch Exterior

WRITE FOR CATALOG "C-12"

THE CARLYLE JOHNSON MACHINE CO. MANCHESTER CONN

20 Horse Power Century Type SC
Multi-Speed Constant Torque Squirrel Cage Induction
3 and 2 Phase Motor

MULTISPEED

Constant Torque Motors
Constant Horse Power Motors
Variable Torque Motors

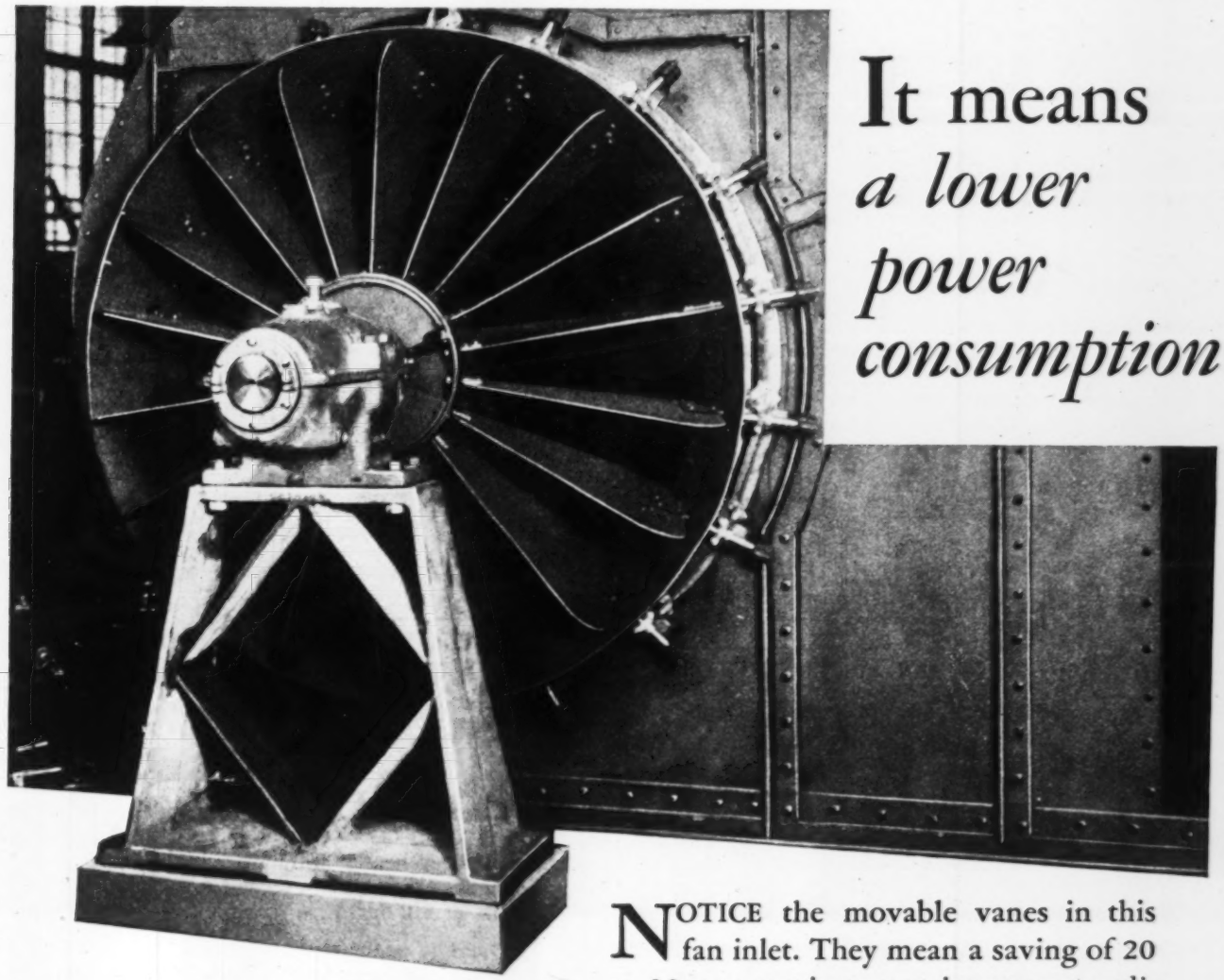
Multiple speeds from a squirrel cage motor, with push button or drum control, offer a solution of many drive problems—among machine tools, woodworking machinery, mixers, blowers, stokers, conveyors, etc.

They are built regularly for 2, 3 and 4 speeds, with wide or narrow speed ranges like 1800-1200 or 1800-600 down to 900-450 r. p. m. (60 cycle). Special speed combinations available as described in bulletin 13-1.

CENTURY ELECTRIC COMPANY
1806 Pine St. St. Louis, Mo.
40 U. S. and Canadian Stock Points and more than 75 outside thereof

Century MOTORS

"THEY KEEP A-RUNNING"



It means *a lower power consumption*

NOTICE the movable vanes in this fan inlet. They mean a saving of 20 to 30 per cent in motor input over ordinary damper regulation, and large savings over slip-ring motor control. Control of air pressure and volume becomes *automatic* with constant speed motors.

The Sturtevant Vane Control has been quickly accepted by the prominent stations from coast to coast. It would be a pleasure to send you complete information on Sturtevant Vane Controlled F. D. and I. D. Fans. Please address our nearest Branch Office.

B. F. STURTEVANT CO.
Hyde Park, BOSTON, MASS.

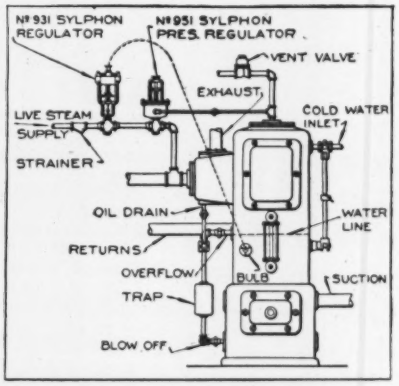
Plants at: Berkeley, Cal. ✎ Camden, N.J. ✎ Framingham, Mass. ✎ Galt, Ontario ✎ Hyde Park, Mass. ✎ Sturtevant, Wis. ✎ *Canadian Representative:* Kipp Kelly, Ltd., Winnipeg. *Offices in Principal Cities.*

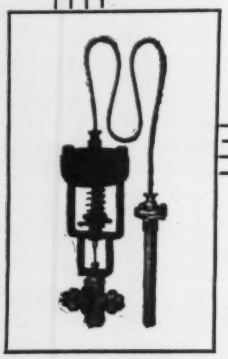
Sturtevant *Forced Draft Induced Draft* FANS

REG. U.S. PAT. OFF.

STEAM TURBINES ~ FORCED AND INDUCED DRAFT FANS ~ ELECTRIC MOTORS
FUEL ECONOMIZERS ~ GENERATING SETS ~ AIR PREHEATERS

Sylphon
TRADE MARK





No. 931 Regulator on Feed Water Heater

Regulating temperature of feed water by injection of live steam to supplement exhaust steam, controlled from temperature of feed water.

ECONOMY in Feed Water Heating

A Sylphon Regulator on a feed water heater automatically feeds live steam only when exhaust steam is insufficient to maintain feed water temperature at 210 deg. F.

It eliminates absorption of oxygen by open water and thus prevents corrosion of tubes, steam lines and turbine blades.

Rigid economy in the power production for your plant is best accomplished with Sylphon Automatic Temperature control. In the reduction of manufacturing and operating costs in hundreds of plants, it has demonstrated its absolute dependability.

More Detailed Information on Request

We will be glad to send you more complete details showing the advantages by the installation of Sylphon Temperature Regulators in your plant. No obligation on your part.

Don't Forget to Visit Our Booth at the Show

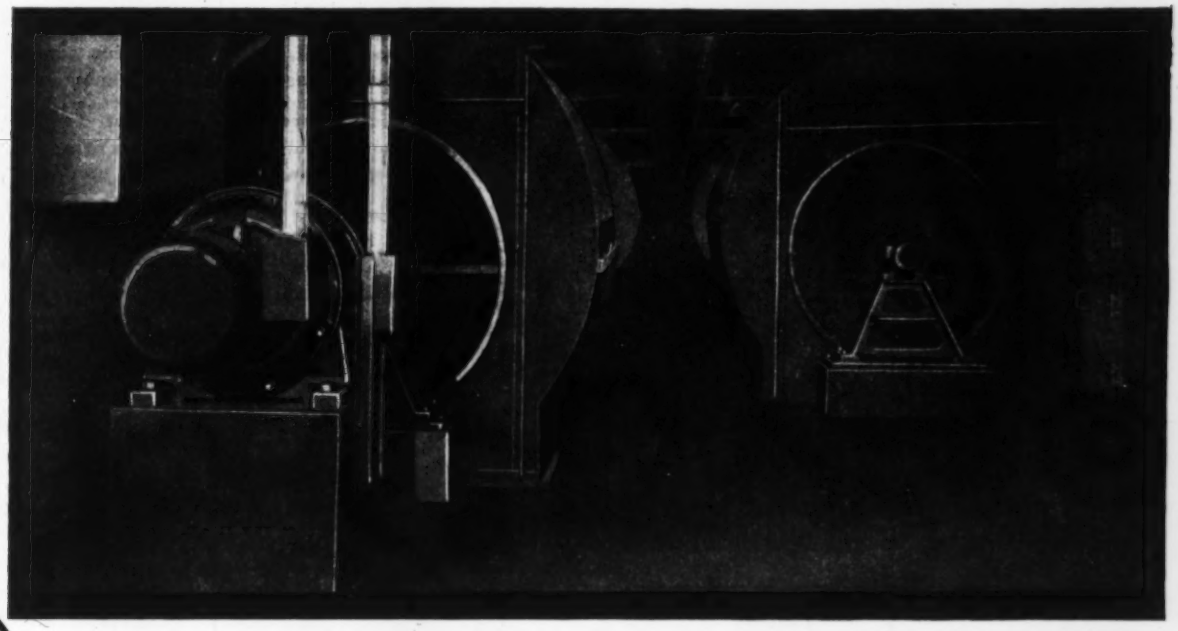
Write for Bulletin M-125

FULTON SYLPHON CO.
KNOXVILLE, TENN., U.S.A.

Representatives in all Principal Cities in U. S. A.—European Representatives, Crosby Valve & Eng. Company, Ltd., 41-2 Foley St., London, W. I., England—Canadian Representatives, Darling Bros., Ltd., 140 Prince St., Montreal, Que., Canada.

"Buffalo"

DRAFT FANS



This impressive group (8 of them) serves a large power company

DRAFT fans, particularly in large power plants, are a vital factor in final efficiency. Subjected as they are to continuous operation, with large scale fuel consumption and accurate measurement of results, only efficient and sturdy fans can give satisfactory service.

The list of users of Buffalo forced and induced draft fans includes most of the large public utilities in America. They know from experience that advanced engineering and modern construction are worth all they cost. Why not have the same kind of fan service in your plant?

BUFFALO FORGE COMPANY

148 Mortimer St., Buffalo, N. Y.

In Canada: Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

FANS BLOWERS UNIT HEATERS

CARBEX

—a super-refractory of the finest silicon-carbide type, made into bricks or shapes of exceptional smoothness and capable of the greatest possible resistance to internal and surface disintegration and to all other destructive influences of high furnace heat and hard physical punishment.

Carbex Bricks and Blocks are essential to economical maintenance in every high-temperature boiler furnace because of their extreme hardness, density, and resistance to softening, cracking, checking and surface disintegration. Clinkers do not penetrate or fuse with the surface. Cleaning tools will not break off corners or sections of the lining. Heavy superimposed weight from upper walls is supported without weakness. Air-cooled walls built with Carbex are very effective, as Carbex transmits heat seven times as fast as fire clay. Water walls faced with Carbex admit of great heat absorption, but maintain a good radiant surface.

CARBEX offers decided annual economy and should be utilized under these furnace conditions:

Where extreme heat prevails from high boiler pressure and temperature, from a high rate of forcing for capacity increase, or from the use of preheated combustion air for fuel economy and faster steaming rate.

Where severe and frequent temperature changes occur as in oil or gas firing, in high-pressure waste-heat boilers, etc.

Where more rapid generation and transfer of heat will result in increased or better production or more economical operation as in metallurgical furnaces.

Where excessive clinker formation clogs the operation of stokers or gives trouble for other reasons.

Where the fuel is of a nature to produce excessive slagging and erosion of ordinary fire clay walls under any furnace temperature.

A Carbex lining 15 to 35 in. high in the clinker zone, all around the fire box, including the front wall, will nullify the principal causes of furnace failure. Usually 4½ in. of Carbex lining with header courses and backed up by the same thickness of ordinary fire brick to check outward flow of heat, affords thorough protection. Under severe conditions, 9-in. wall thickness of Carbex will meet every requirement.

Carbex Bricks and Blocks, the latter made to any desired contour, effect enormous annual material and labor savings through reduction in the frequency of lining renewals.

Tell us the make, capacity and forcing rate of your boilers, what fuel and firing devices you are using, what furnace temperatures are maintained and give us inside furnace dimensions or blue prints, so that our Engineers can submit recommendations, with Carbex performance data and costs.

Write for this FREE BOOKLET

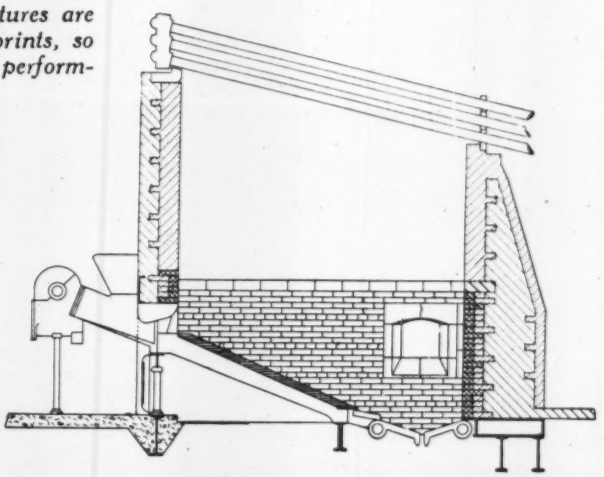
which tells exactly what you should know about refractories under all boiler conditions, and describes our complete lines of Carbex and Steel Mixture bricks and blocks for use at all furnace locations.

McLeod & Henry Co.

Specialists in Furnace Refractories for More Than a Hundred Years

19 Monroe St. - Troy, New York

Branches: New York, Boston, Buffalo, Cleveland, Detroit

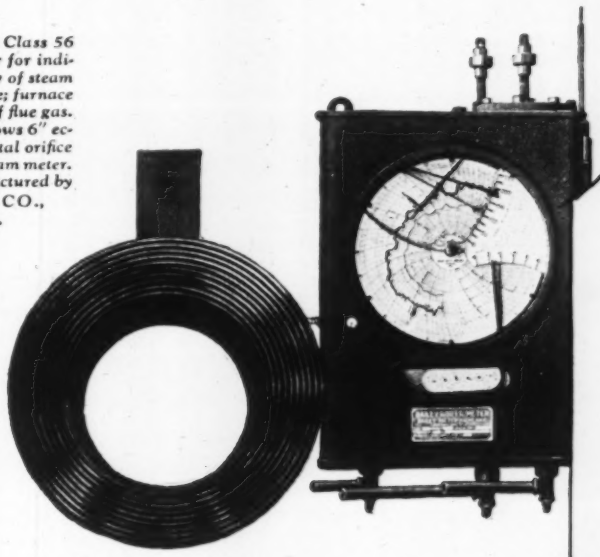


Typical Carbex lining for furnace of stoker-fired boiler, showing Carbex bricks; Carbex composite door arch and Steel Mixture header blocks.

BAILEY METERS *have*

Monel Metal Orifice Plates

AT RIGHT: Type D-26, Class 56 Bailey boiler steam meter for indicating and recording flow of steam from boiler; air to furnace; furnace draft; and temperature of flue gas. Left hand illustration shows 6" eccentric type of Monel Metal orifice plate for high pressure steam meter. Meter and orifice manufactured by BAILEY METER CO., *Cleveland, Ohio.*



A SIMPLE STATEMENT OF A BASIC ENGINEERING PRINCIPLE

1. DESIGN is THE idea—the starting point of Production. It is the First Essential.

2. WORKMANSHIP is led and directed by Design, it is the human touch that shapes mass into form. It is the Second Essential.

3rd *of the* Essential

MATERIAL is the backbone of performance. Upon it, depend the efficiency and service-life of the product which Design and Workmanship have evolved. It is the

Leading Manufacturers appreciate the importance

All types of power plant equipment—from the largest turbines to the most delicate instruments—must be manufactured with a view to the 3 Essentials. Particularly in the case of measuring instruments, material—the 3rd Essential—is of utmost importance.

The Bailey Meter Company, realizing that the orifices of its products play a most vital part in assuring accuracy, has spent years in the study of different types of orifices and the materials from which they may be made. As a result of this research, this Company states:

"Wear and corrosion have been overcome by the use of Monel Metal as a standard material for *all* Bailey steam and water orifices."

In other words, this Company, like other leading manufacturers, has concluded that the employment of Monel Metal is the best assurance of long life and dependable performance.

If you require additional information regarding Monel Metal's remarkable combination of properties, write direct.

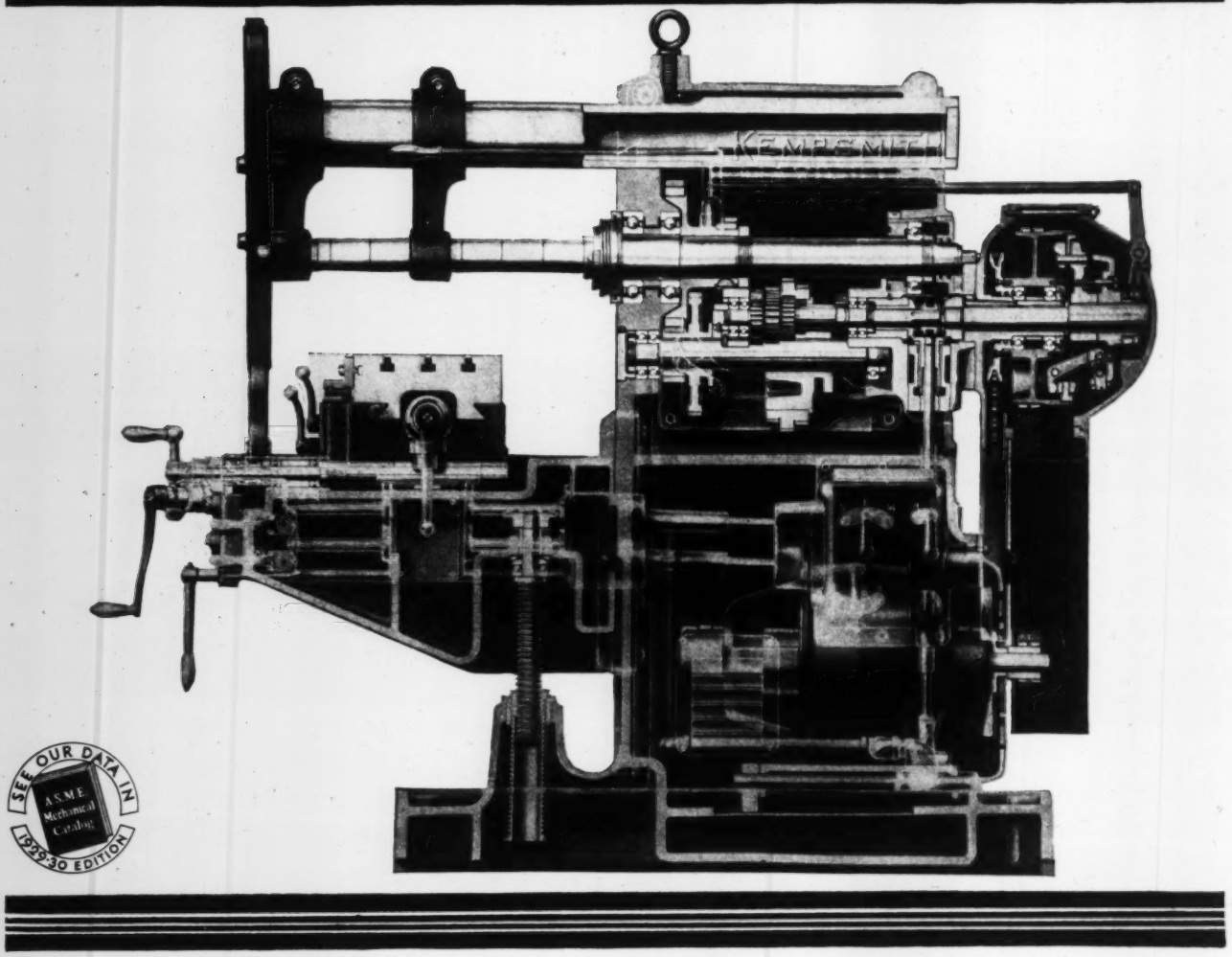
SEND FOR "LIST B" OF MONEL METAL & NICKEL LITERATURE

MONEL METAL

Monel Metal is a technically controlled Nickel-Copper alloy of high Nickel content. It is mined, smelted, refined, rolled and marketed solely by The International Nickel Company, Inc. The name "Monel Metal" is a registered trade mark.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

MONEL METAL



Rigidity and accuracy are useless

. . . unless they are lasting

KEMPSMITH, with forty years' experience in the building of quality milling machines has standardized on New Departure Ball Bearings throughout, including the main spindle, because:

1. New Departure preloaded spindle bearings give maximum rigidity under the heaviest working loads.

2. This rigidity is permanent, for wear in properly mounted ball bearings is too slight to be measured.

3. New Departures are accurate at all speeds—and remain so far longer than other types of anti-friction bearings.

4. They are most efficient—a spindle equipped with New Departures may easily be turned by hand when fully pre-loaded—rigidity is not gained by sacrificing power.

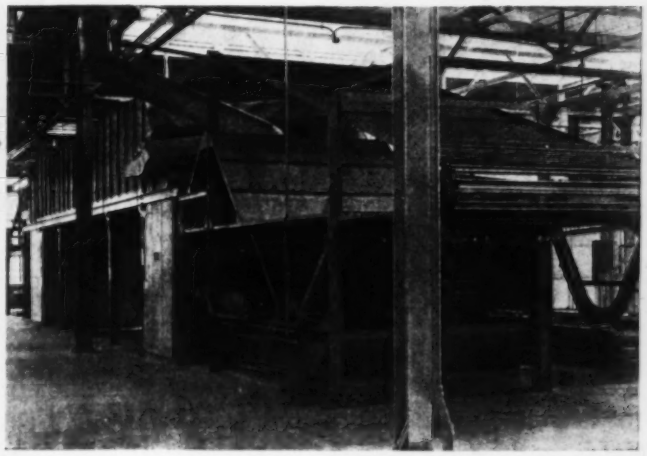
With the recent trend toward greatly increased cutting speeds, engineers are careful to specify bearings with a capacity for high speed—heavy duty—and a life equal in length to that of the machine itself—that means New Departures.

The New Departure Manufacturing Company, General Offices and Main Works, Bristol, Connecticut; Detroit, Chicago, San Francisco.

New Departure Ball Bearings

1359

MAEHLER



Maehler continuous conveyor oven for automatically dipping and baking enamel parts—one of the many units of the complete Maehler installation of industrial ovens at the plant of Lyon Metal Products, Inc., one of largest manufacturers of metal cabinets, furniture, display and storage equipment

What is the biggest part of the job?

MORE ESSENTIAL than the specifications, even more important than the equipment itself, is the ability of Maehler engineers in fitting that equipment to your particular needs.

The increasing number of leading manufacturers who are adopting complete Maehler industrial oven installations simply adds accumulative evidence of Maehler responsibility.

The new Lyon Metal Products finishing plant is a typical example of the systematic thoroughness with which Maehler equipment is built and engineered to deliver definite results.

This job includes a battery of mono-rail ovens for baking long parts, a set of continuous conveyor ovens for dipping and baking smaller enamel units, and combination finishing ovens with spray booths for the final coating of special parts.

All are equipped with Maehler-Universal Heaters, which insure uniform quality of bake, and incinerate combustible vapors thereby eliminating all baking hazards.

The whole series of processes is planned and timed to a precise schedule. Operation goes on smoothly and with clock-like regularity. Production continues at peak efficiency—proof that Maehler service is the biggest part of the job.

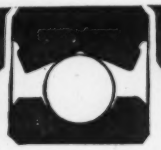
Put your problem in the capable hands of Maehler engineers, and you can depend on the results. Send for booklet, "Heat from Hazard."

THE PAUL MAEHLER COMPANY
2204 W. Lake Street, Chicago, Ill.

Universal Economy

OVENS

WGK—7490



Bearings for Every Purpose

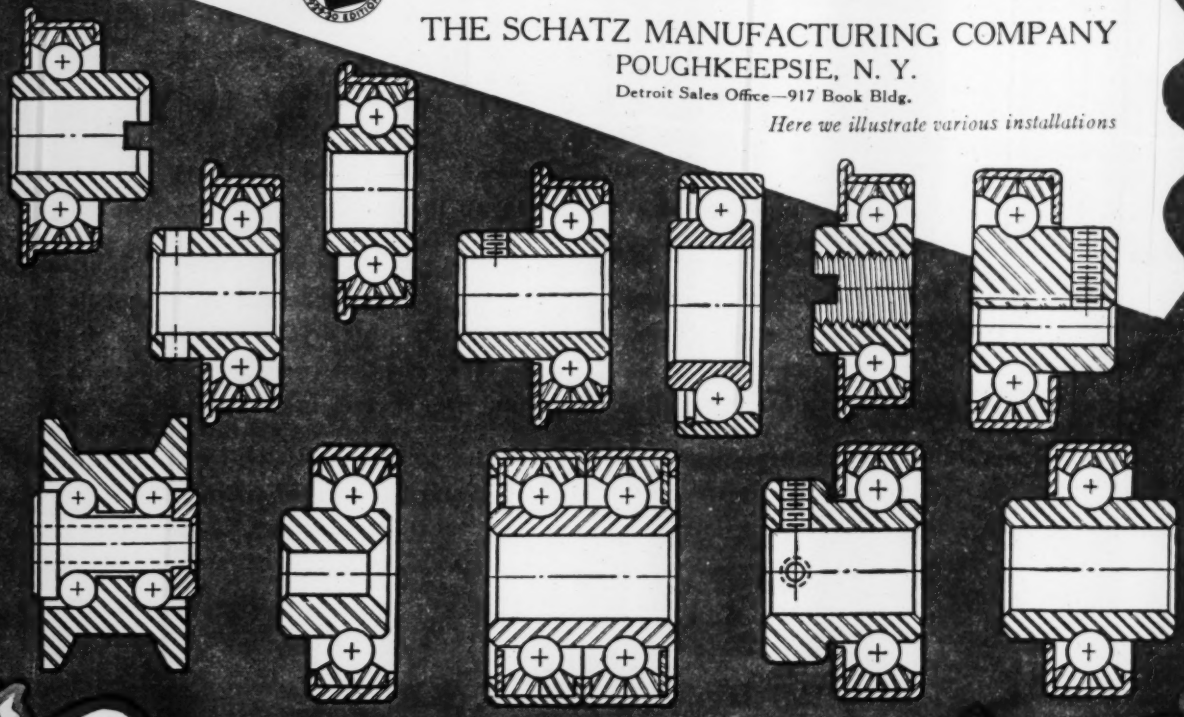
IF you use bearings, we can supply you with *exactly* the type of bearing needed and at very moderate cost. We make bearings for thousands of different uses—anything from a control switch for an electric sign board to an automobile or a battleship. Folding doors, roller skates, cotton spinning machines, electric cleaners. In every conceivable industry and for every conceivable purpose.

WE design special types of bearings for you, or suggest more economical installations. Our line of "stock" bearings is also available. "Commercial" bearing service is as efficient as "Commercial" Annular Ball Bearing itself. You will obtain the famous three-point contact. Speeds up to 2500 R.P.M. A larger number of balls. Precision and quality.

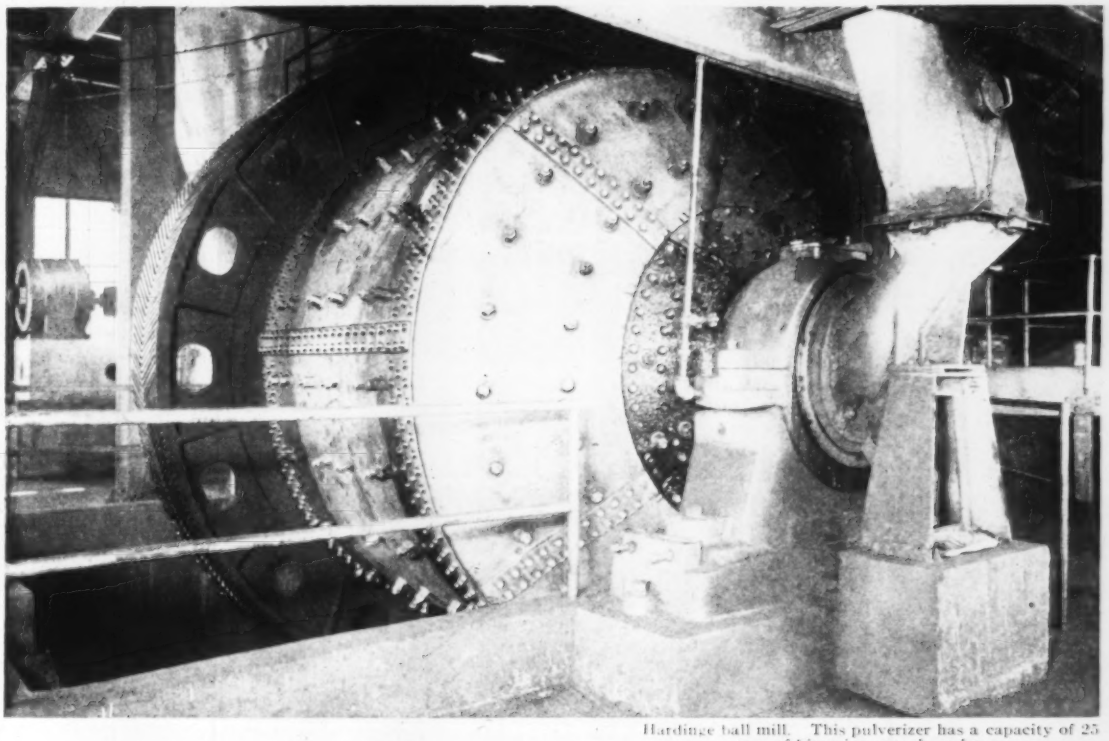
Send for Illustrated Catalog, Discount Sheets and Samples

THE SCHATZ MANUFACTURING COMPANY
POUGHKEEPSIE, N. Y.
Detroit Sales Office—917 Book Bldg.

Here we illustrate various installations



"Commercial"



Hardinge ball mill. This pulverizer has a capacity of 25 tons of bituminous coal per hour.

Continuous Operation Low Maintenance Characterize Hardinge Pulverizers

Hardinge pulverizers hold the record for continuous operation. The longest uninterrupted run was in 24 hour service, pulverizing ore, for 372 days.

Low maintenance is definitely established by the record performance of the pulverizer illustrated. During 1928 this Hardinge mill pulverized 31,071 tons of river anthracite and 12,200 tons of bituminous coal. The maintenance was but 1.94 cents per ton.

SEE OUR DATA IN A.S.M.E. Reference Catalog 1929-30 EDITION

FOSTER WHEELER CORPORATION

165 Broadway, New York, N. Y.

Branches in Principal Cities

Foreign Associates—
Foster Wheeler Limited: London, England.
Societe Anonyme Foster Wheeler: Paris, France.
Foster Wheeler Limited: Toronto—Montreal, Vancouver, Canada

FOSTER WHEELER

A SPECIALIZED LINE OF

INDUSTRY demands highly specialized control equipment. It no longer is sufficient that control apparatus is automatic. Each starter must possess individual characteristics which adapt it to a special cycle of operation.

Allen-Bradley is a leader in the development of specialized control apparatus. In addition to offering an extensive line of standard control, Allen-Bradley serves its customers by constantly adding specialized equipment to meet new demands.

for

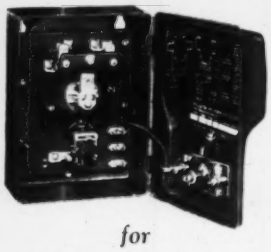
OIL BURNER CONTROL

Bulletin 719 Oil Burner Control Panel operates in conjunction with oil burner safety shunting controls where these controls lack sufficient capacity to switch motor current.

The magnetic switch starts motor when thermostat makes contact, if pressure switches, low water gauges, etc., are closed. If oil burner fails to ignite, temperature relay opens switch and stops motor. Overload protection also can be provided.

Ratings: — Single Phase — 1½ H. P., 110 V.; 3 H. P., 220 V. Polyphase — 3 H. P., 110 V.; 5 H. P., 220 V. 7½ H. P., 440-550 V. Steel cabinet can be locked to prevent tampering.

BULLETIN 719



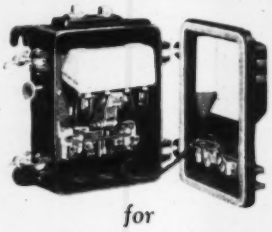
for

SINGLE PHASE MOTORS

Bulletin 707 Single Phase Starting Switch is a double-pole magnetic switch with maximum rating of 1½ H. P., 110 V.; 3 H. P., 220 V., 25 to 60 cycles, for motors operating refrigerating machines, compressors, pumps, oil burners and other devices governed by 2-wire or 3-wire pilot controls. Switch coil has double winding, permitting switch to be used interchangeably up to and including 1½ H. P., for 110 or 220 V. motors by changing coil connections.

A Resisto-therm Overload Relay provides accurate and reliable overload protection.

BULLETIN 707



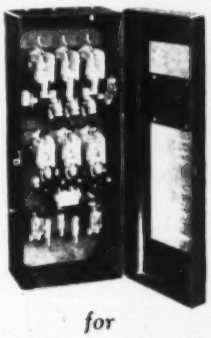
for

SPLASH-PROOF SERVICE

Bulletin 709WT Splash-proof Switches are standard Allen-Bradley Bulletin 709 Across-the-Line Switches enclosed in cast iron splash-proof cabinets. These switches are ideal for laundries, creameries, packing plants, rayon plants, and other factories requiring splash-proof switches. They also are suitable for dusty installations such as found in flour mills, cement plants, etc. Special splash-proof start-and-stop buttons and relay reset buttons are provided and the hinged cover has a rubber gasket to exclude spray and moisture.

These switches are rated for single phase motors up to 3 H. P., 110 V.; 5 H. P., 220 V., and for polyphase motors up to 5H. P., 220 V., and 7½ H. P., 440-550 V.

BULLETIN 709WT



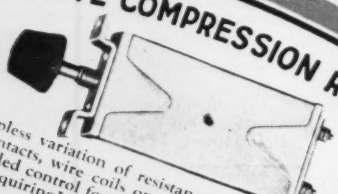
for

AUTOMOBILE PLANTS

Bulletin 711-712 Across-the-Line Starting Switches have outside-operated disconnect switches and separate test jacks. Fuse Clips can be provided. These switches eliminate much wiring and conduit, and permit easy rearrangements of motors and starters when plant layout changes are necessary. Test jacks provide safe means for determining motor load. Ratings up to 10 H. P., 110 V.; 30 H. P., 220 V.; 60 H. P., 440-550 V.

BULLETIN 711-712
WITH DISCONNECT SWITCHES

GRAPHITE COMPRESSION RHEOSTAT



Stepless variation of resistance without sliding contacts, wire coils, or grid resistors. Unrivalled control for thousands of applications requiring Velvet Smooth Current Control.

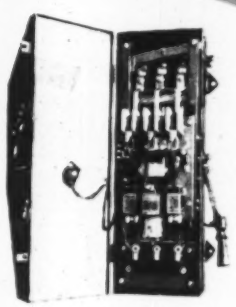
Allen-Bradley

SETS THE PACE

NEW AUTOMATIC CONTROL

The automatic control devices, illustrated on these pages, are examples of specialized equipment. This new line demonstrates the ability of the Allen-Bradley Company to match the need with the correct control. The prestige of the Allen-Bradley trade-mark makes this line of automatic switches an asset alike to the machine builder and the factory superintendent.

Masters of industry look to Allen-Bradley for the unique and the new in control design.

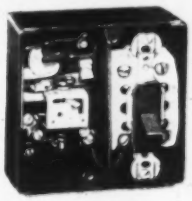


for

SQUIRREL CAGE MOTORS

Bulletin 648 Resisto-Transformer Starter has graphite compression resistors in series with auto-transformer when starter is first connected to line. Resistors eliminate current inrush of ordinary starting compensator and prevent voltage fluctuation during starting. Motor is accelerated by steplessly reducing starting resistance. Ratings:—Up to 75 H. P., 220 V.; 125 H. P., 440-550 V., at 50 or 60 Cycles, and 30 H. P., 220 V., 50 H. P., 440-550 V., at 25 or 30 Cycles.

BULLETIN 648



for

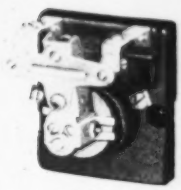
SMALL A.C. & D.C. MOTORS

Bulletin 825 Fractional Horse Power Overload Breakers are designed to protect small A. C. and D. C. Motors up to 1 H. P., 125 volts, and 1½ H. P., 250 volts, on refrigerating machinery, pumps, fans, machine tools, compressors, etc. Combinations have been developed for manual starting or for two-wire control, such as a pressure switch, float switch, etc. The maximum current rating is 15 amperes at 125 and 250 volts.

The contacts are silver plated, with arc barriers and magnetic blow-outs to assure ample current-interrupting capacity.

The overload breaker will accurately repeat its tripping operation on overload an indefinite number of times.

BULLETIN 825



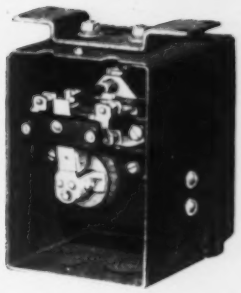
for

A. C. & D. C. SWITCHING

Bulletin 201 D. C. and Bulletin 701 A. C. Contactors are designed for electric ranges, water heaters, steam vulcanizers, fire alarms, oil burners, refrigerators, traffic signal systems, and other applications requiring small automatic single or double pole contactors. The current rating is 15 amperes for the double pole contactor and 30 amperes for the single pole contactor. The magnet coil can be wound for any standard voltage from six volts to 230 volts.

These contactors are available for two-wire separate control, 2-wire common control, and 3-wire pilot control. Silver contacts are used.

BULLETIN 201 D. C.
BULLETIN 701 A. C.



for

A. C. REVERSING SERVICE

Bulletin 704 Alternating Current Reversing Switch consists of two double-pole magnetic contactors, mounted back to back with an interlocking pin between them. When contactor on one side closes, it pushes interlocking pin against contactor arm of opposite switch. If opposite switch is already closed, interlocking pin cannot move and first contactor remains open.

Furnished for 2 and 3-wire control. Maximum rating 1 H. P., 110 V.; 1½ H. P., 220 V., single phase. 2 H. P., 220, 440, 550 V. polyphase.

BULLETIN 704

Bradley

IN CONTROL DESIGN

SEND FOR BULLETINS

ALLEN-BRADLEY CO.
490 Clinton St., Milwaukee, Wis.

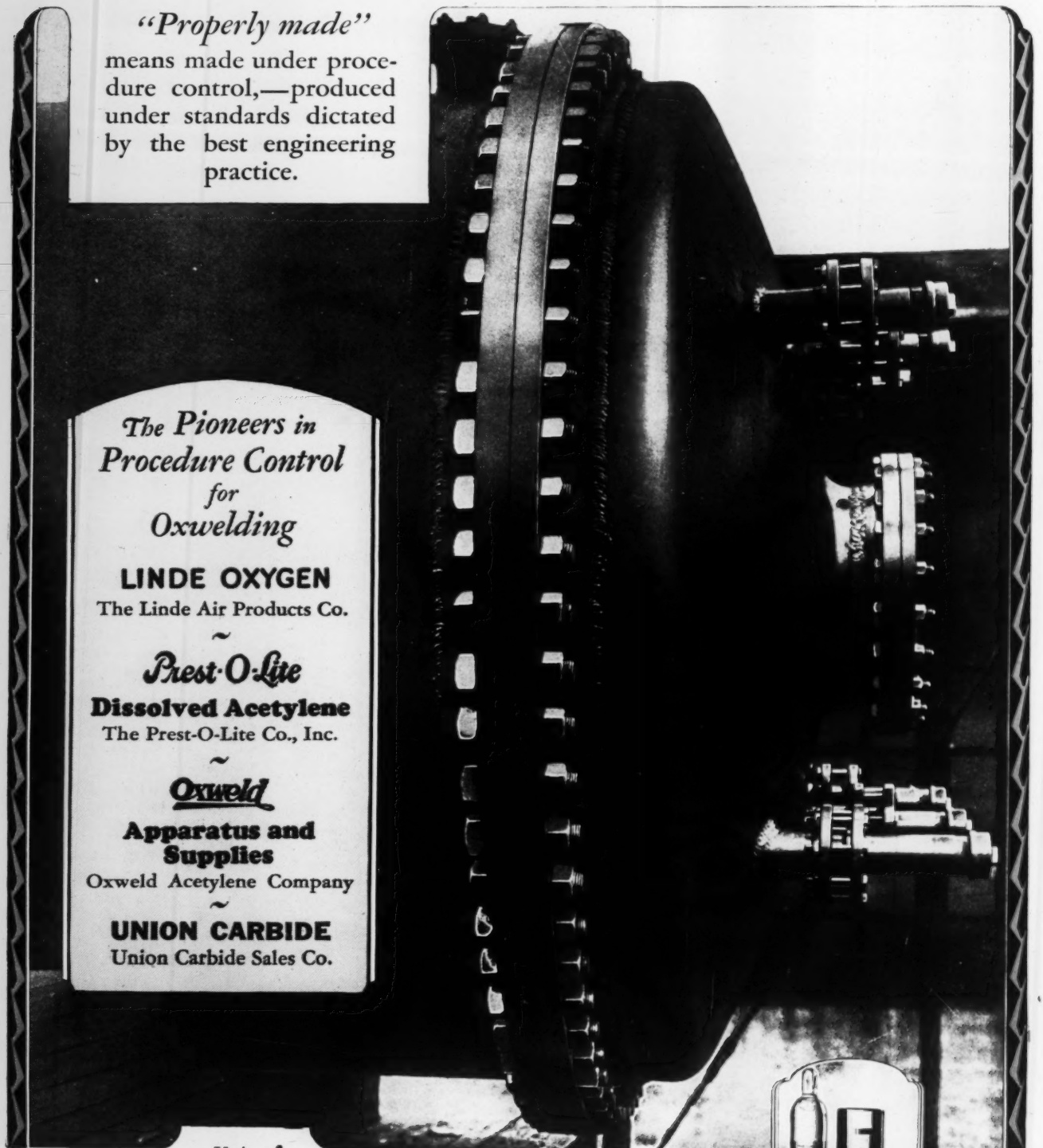
Send us bulletins describing new Automatic Switches for .....

Name .....

Address .....

"A properly made oxy-acetylene welded joint is as strong as the base metal, fully 100% efficient . . . ."

"Properly made" means made under procedure control,—produced under standards dictated by the best engineering practice.



The Pioneers in Procedure Control for Oxwelding

LINDE OXYGEN
The Linde Air Products Co.

~

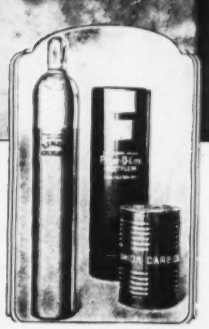
Prest-O-Lite
Dissolved Acetylene
The Prest-O-Lite Co., Inc.

~

Oxweld
Apparatus and Supplies
Oxweld Acetylene Company

~

UNION CARBIDE
Union Carbide Sales Co.



Units of

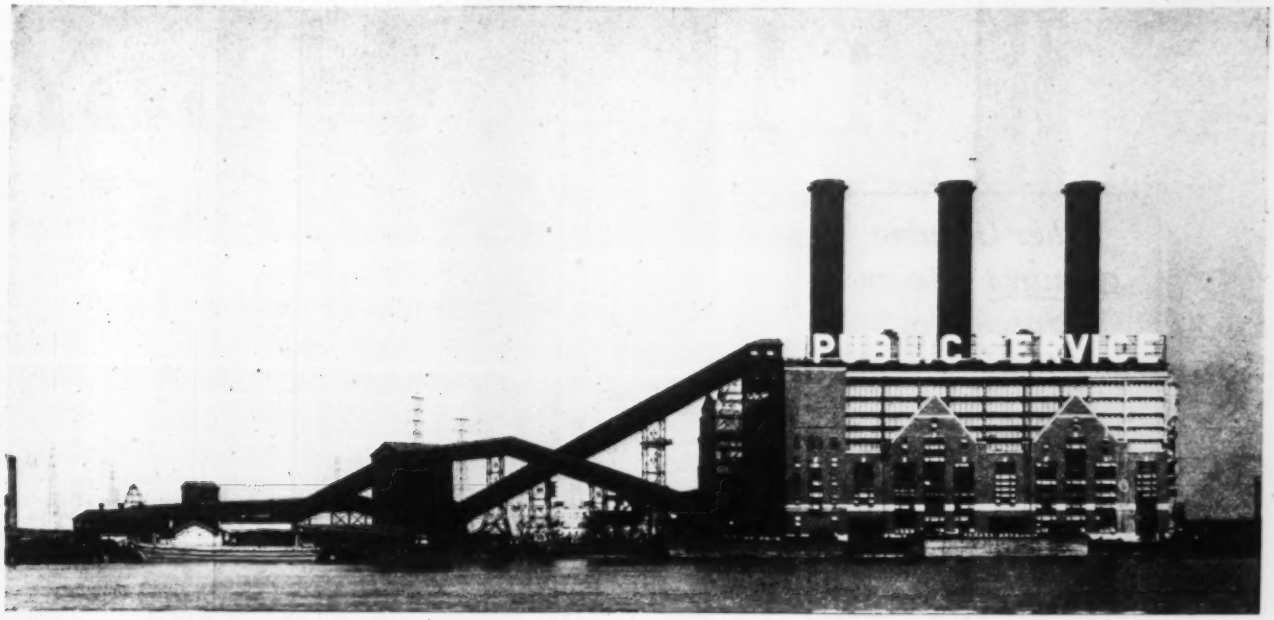
UNION CARBIDE AND CARBON CORPORATION

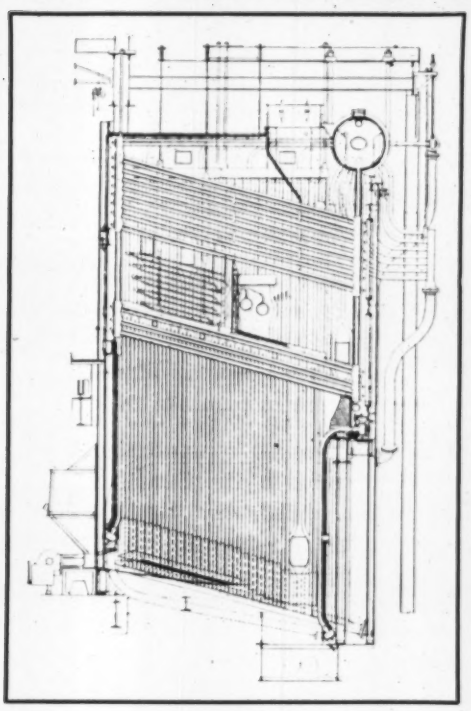
General Offices UCC *Sales Offices*

30 East 42nd Street, New York, N. Y. In principal cities of the country

64 Linde Plants—45 Prest-O-Lite Plants—154 Oxygen Warehouse Stocks—138 Acetylene Warehouse Stocks—38 Apparatus Warehouse Stocks—235 Carbide Warehouse Stocks.

Now is the time to put Eveready Prestone, the perfect anti-freeze, in your automobile radiator—Eveready Prestone is guaranteed by National Carbon Company, Inc., unit of Union Carbide and Carbon Corporation.





See our data in 1929 1st Edition A.S.M.E. Mechanical Catalog

SPRINGFIELD
BOILERS—WATER WALLS
SECTIONAL—ALL STEEL
ALL SIZES—ALL PRESSURES

KEARNY STATION
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
KEARNY, N. J.

Public Service Production Company

Engineers and Constructors

3—2290 Horse Power SPRINGFIELD Boilers built for 400 lbs. steam working pressure, installed in the above plant.

To the left is illustrated the sectional side elevation of the SPRINGFIELD Boilers and Water Walls as installed in the KEARNY STATION.

Water Walls completely enclose settings at both sides from floor line to roof, and at front and rear up to the boiler headers. Practically all masonry eliminated.

Write for your copy of our catalog.

The SPRINGFIELD Water Wall embodies, as far as possible, the same materials and methods of construction as employed in the manufacture of our Water Tube Boiler. They are built in sections or panels wherever possible and assembled and tested in the shop and shipped as a complete unit. These Water Walls are designed to suit the particular furnace design and working pressure with which they are to be used, and are built with wide tube spacing, or with the tubes so closely spaced that they actually touch. The feeder and riser connections from the boiler to the water walls are proportioned to supply the steam generating surface with an abundance of water without interfering or disturbing the water level in the boiler.

SPRINGFIELD BOILER CO.
SPRINGFIELD, ILLINOIS

OFFICES:
Chicago
New York
Boston
Philadelphia
Richmond
Atlanta
Pittsburgh

SPRINGFIELD BOILERS

OFFICES:
Cincinnati
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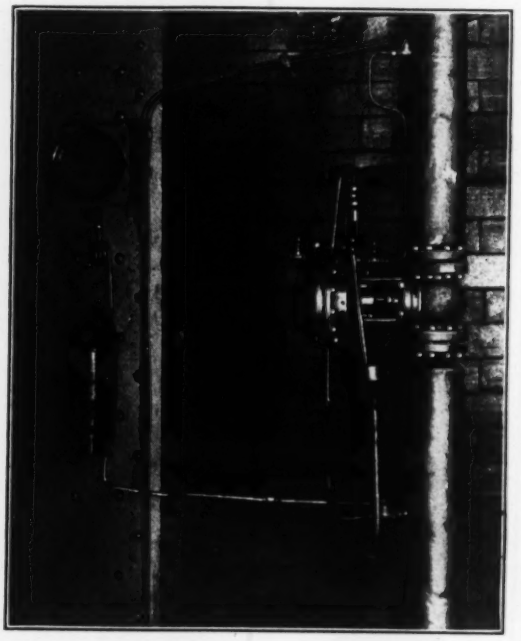


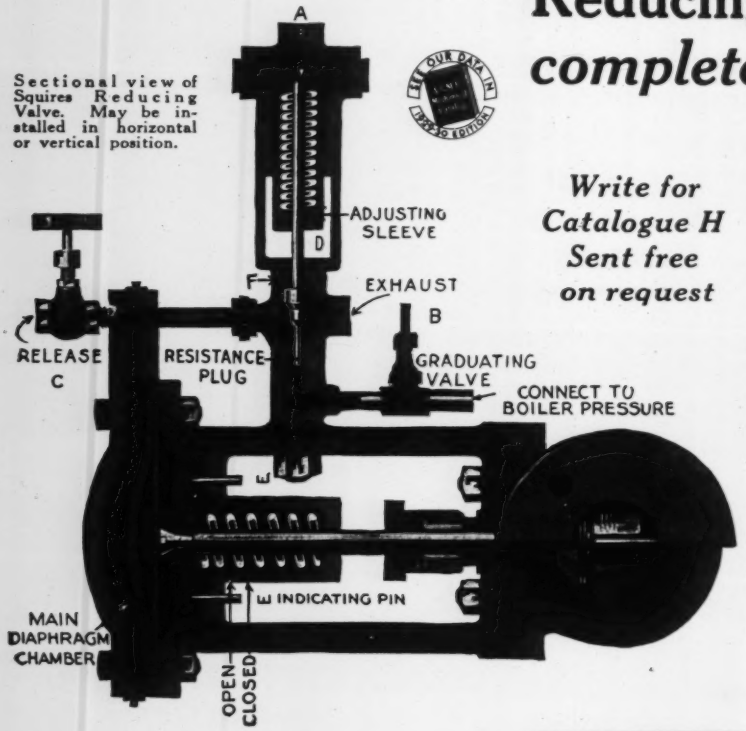
Installation of Squires Reducing Valve in a leading central station. Notice the low pressure gauge registering exactly the required 200 lb.

Other Genuine Squires Steam Specialties

Specialists for over 30 years in steam problems makes available a fund of experience which is at your service to call upon. Write us about applications of any of these Squires Specialties:

Standard Genuine Squires Steam, Air and Blast Traps
New Genuine Squires Steel Trap
Class "E" Pump Governor
Class "H" Pump Governor
Class "B" Excess Pump Governor
Boiler Feed Water Controllers

Because SQUIRES Reducing Valves gives *complete satisfaction*—



Sectional view of Squires Reducing Valve. May be installed in horizontal or vertical position.

Write for Catalogue H Sent free on request

they are the selection of leading engineers who run their plants on an economical basis. Quality products that stand the wear of modern high-pressure service are furnished by Squires to the foremost plants of the country.

Simple design, rugged construction and dependable action mark the Genuine Squires Reducing Valve. Made from the best of materials, it stands up under the heaviest work for long periods of service.

Controlled by a pilot valve which is governed by the low pressure side, maintains delivery pressure always exact. The Squires Reducing Valve holds pressure constant by a single reduction from 500 lb. or less initial pressure to any desired reduced pressure.

Write for full description of this master reducing valve.

Insist on the Genuine **Squires** Steam Specialties

THE C. E. SQUIRES COMPANY E. 40TH ST. & KELLEY AVE., CLEVELAND

You Need This Book

. . . If you wish to keep posted on developments in modern High Pressure Steam Piping.

The report shows the results of a well planned series of tests on piping materials as recommended by the American Engineering Standards Committee for 1350 lbs. W. S. P.

Although only high operating conditions were considered, the results should be of pertinent concern to those interested in steam pressures of 250 lbs. and higher.

Hydraulic tests were also made and pressures carried to 7500 lbs.

To the best of our knowledge no such tests as these have ever been made before and inasmuch as various types of Gaskets, Joints and Lap Facings were used, they should materially assist the Engineer designing a high pressure installation to intelligently select the materials best suited for his requirements.

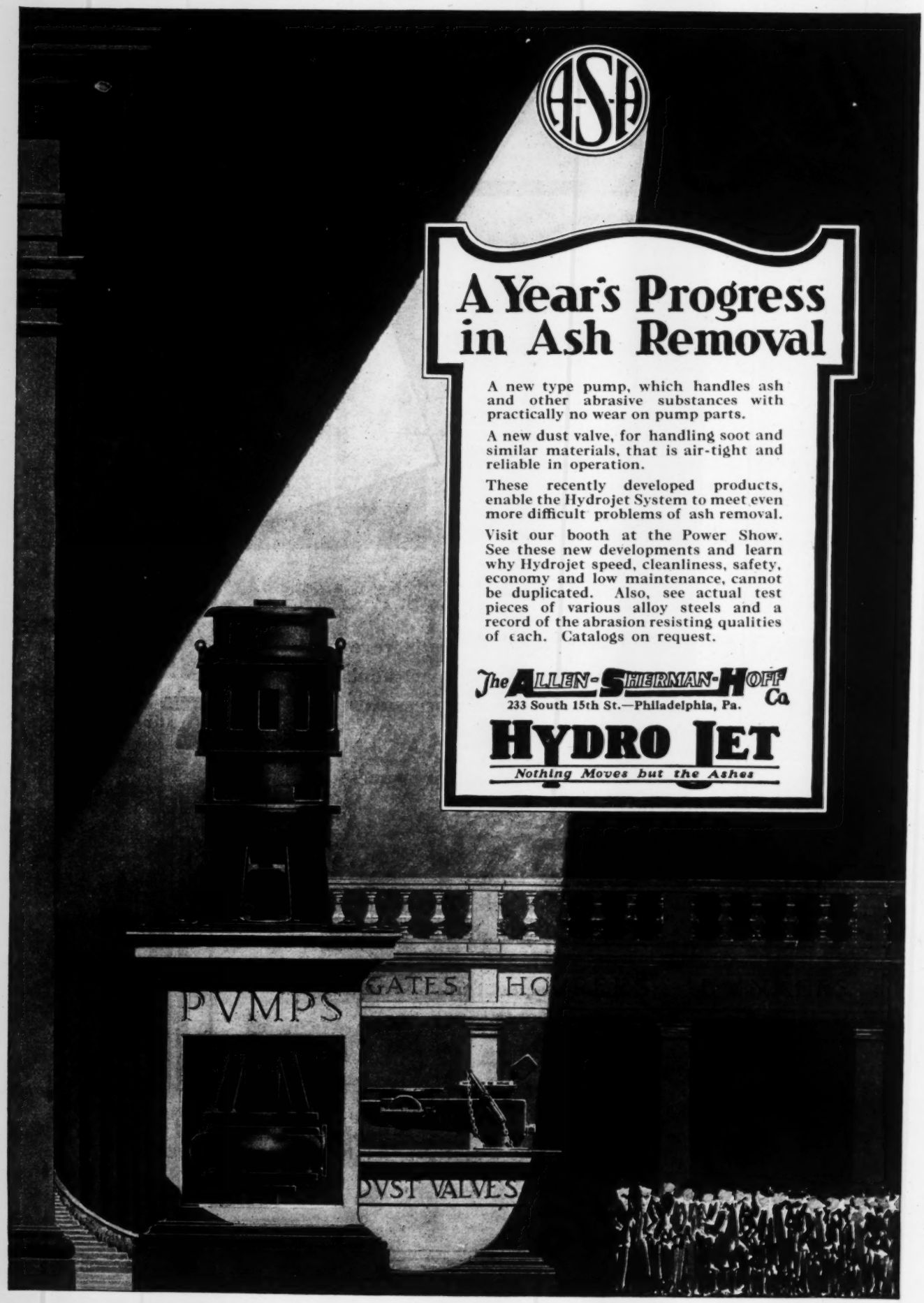
Write for your copy today.

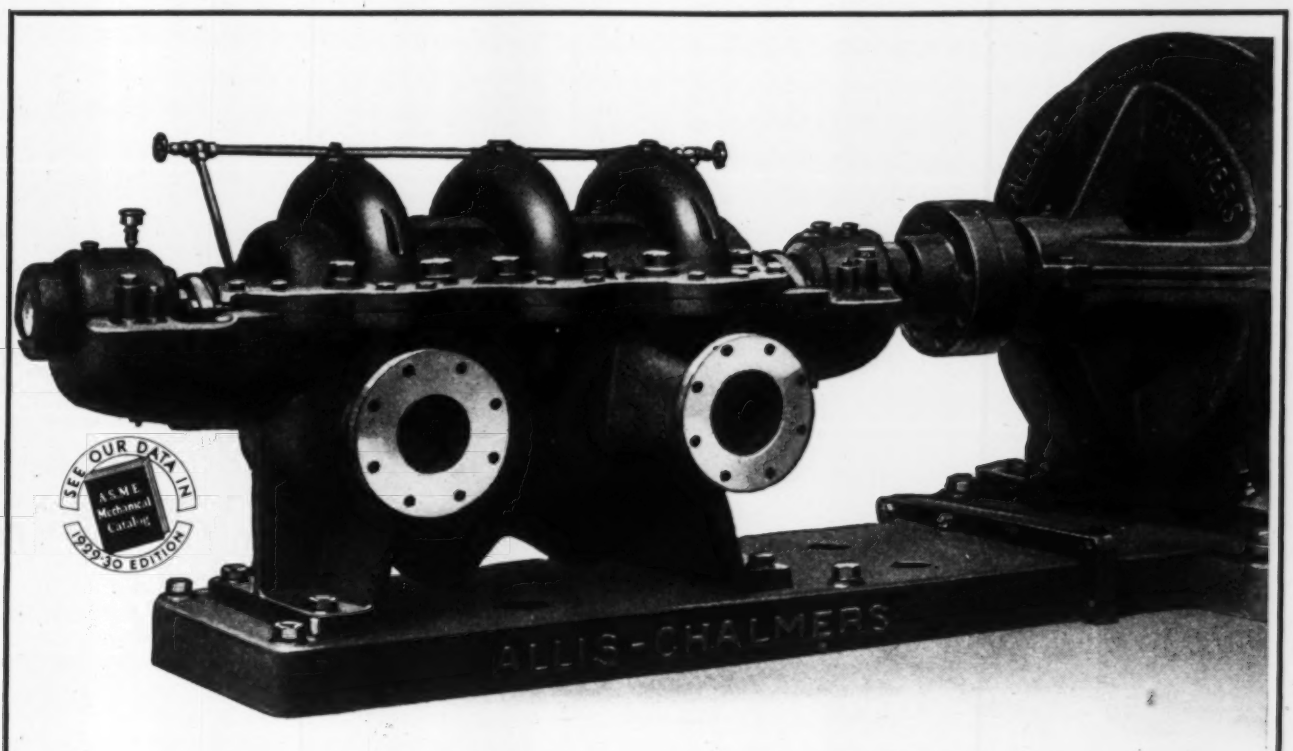
NAVCO

POWER PLANT PIPING

NATIONAL VALVE & MFG. CO., PITTSBURGH, PA.

[ATLANTA CLEVELAND COLUMBUS CHICAGO NEW YORK PHILADELPHIA]


A-S-H
A Year's Progress in Ash Removal
A new type pump, which handles ash and other abrasive substances with practically no wear on pump parts.
A new dust valve, for handling soot and similar materials, that is air-tight and reliable in operation.
These recently developed products, enable the Hydrojet System to meet even more difficult problems of ash removal.
Visit our booth at the Power Show. See these new developments and learn why Hydrojet speed, cleanliness, safety, economy and low maintenance, cannot be duplicated. Also, see actual test pieces of various alloy steels and a record of the abrasion resisting qualities of each. Catalogs on request.
The ALLEN-SHERMAN-HOFF Co.
233 South 15th St.—Philadelphia, Pa.
HYDRO JET
Nothing Moves but the Ashes
PUMPS
GATES
DUST VALVES



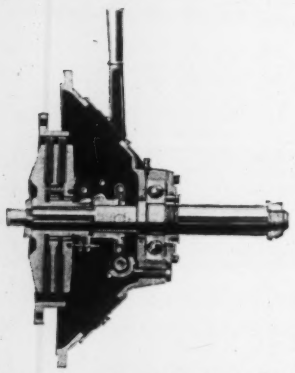
The Modern Multistage Pump

No simpler or more efficient centrifugal pump has been built than the Allis-Chalmers single stage, double suction, horizontally split, volute casing Type "S" pump. The same desirable features of simple volute diffusion passages, double suction impellers minimizing end thrust, and substantial split casing solidly bolted together are now offered in the Allis-Chalmers Type "M" double suction multistage pump. The high efficiency and other desirable characteristics of this improved multistage pump make it the most suitable for heads higher than can be obtained with a single stage pump.

ALLIS-CHALMERS

MILWAUKEE, WIS. U. S. A.

Bucyrus-Erie Shovels use Brown-Lipe Industrial Clutches



Assembly Drawing of Two-Plate, Drum Type Clutch with Housing and Ball Bearings

BUCYRUS-ERIE ten-thirty Shovel stops at nothing—ripping the roots from gigantic trees; hoisting structural steel; dredging swamp lands and digging out hard-pan—in the heart of its machinery is the *Brown-Lipe Industrial Clutch*—built according to Bucyrus-Erie specifications but using the pioneer Brown-Lipe Gear Driving Drum principle.

The Driving Drum of this Brown-Lipe Clutch is fastened to the fly wheel by eight half-inch screws—a far stronger construction than is possible with driving by pins.

The material used in Brown-Lipe Industrial Clutches assures 40% more wear-life and maintains a relatively high coefficient of friction under heat.

Brown-Lipe Industrial Clutches are built to meet the most exacting specifications. A complete engineering department is available for the thorough development of any clutch problem.

BROWN-LIPE GEAR COMPANY

Manufacturers of Transmissions, Clutches & Controls

BROWN-LIPE GEAR CO.

SYRACUSE, N. Y., U. S. A.

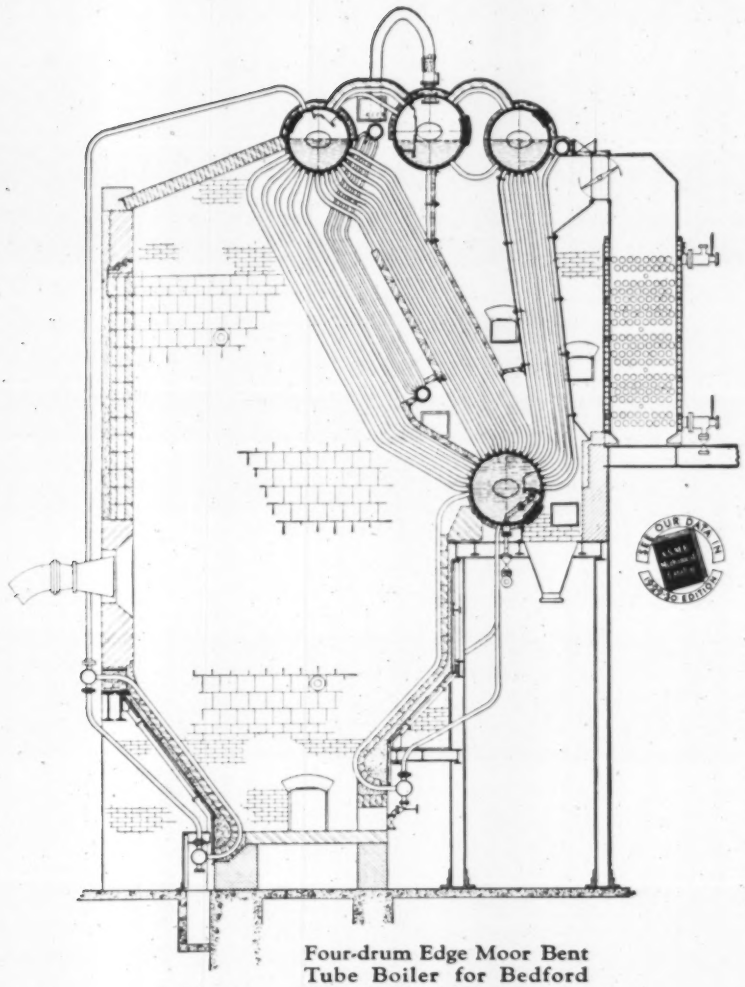
BROWN-LIPE GEAR CO.

SAN FRANCISCO DETROIT LONDON, ENG.

3 Edge Moor Bent Tube Boilers

for new power plant of

BEDFORD PULP & PAPER CO.



Four-drum Edge Moor Bent Tube Boiler for Bedford Pulp & Paper Co., showing superheater, economizer and water walls. 695 h. p. unit for 400 lbs. working pressure.

Three 695 h.p. Edge Moor Bent Tube Boilers, four-drum type, will furnish the steam in the Bedford Pulp & Paper Company's new plant at Big Island, Va. These units are built for 400 lbs. working pressure.

Each boiler furnace will be equipped with Edge Moor Water Walls, bare-tube type, located in rear wall of setting and in hopper bottom.

Other equipment will include Foster convection type superheaters, designed for 100° superheat, Foster economizers and Diamond valve-in-head soot blowers.

The boilers will be fired by pulverized coal, prepared in a Unipulvo system.

We will gladly send further details of this interesting installation at your request.

EDGE MOOR Water Tube BOILERS

STRAIGHT AND BENT TUBE TYPES—WATER WALLS—AIR PREHEATERS

EDGE MOOR IRON COMPANY *Established 1868* EDGE MOOR, DELAWARE

New York Chicago Los Angeles St. Paul Charlotte

HE WHO SIGNS HIS NAME PLEDGES HIS REPUTATION... BY HIS MARK HE LOSES AT ONCE THE SECURITY OF THE NAMELESS

• • •

TO better identify our products we have given them the name of the founder of this company. This decision was made at the beginning of 1929 and during the year we inducted the name and trade mark, as it appears below this text, on products and company effects. Previously goods of our manufacture were designated "High Duty", now they are labeled "Stearns High Duty." The name of the company, however, remains the same, "Magnetic Manufacturing Company, Milwaukee."

The close of 1929 marks a period of full thirty years activity in the magnetic separator industry for Mr. R. H. Stearns. During this span of over a quarter century, Mr. Stearns has taken active part in the practical development of magnetic separation equipment and has contributed much to its present extensive industrial utilization. These years have won Mr. Stearns a well earned recognition in the field. We believe it only fitting, therefore, to add a further measure of recognition by this use of his name as sponsor to the products of the Company; magnetic separators of all types, magnetic pulleys, magnetic clutches, suspended type magnets, apron conveyor magnets, launder magnets, and special magnetic equipment.

R. H. Stearns

President and founder of the MAGNETIC MFG. COMPANY

MAGNETIC MANUFACTURING CO.
283 23rd Avenue Milwaukee, Wis.

HIGH STEARNS DUTY

MAGNETIC EQUIPMENT

IT'S THE TWISTED TEETH THAT LOCK

TANGLEPROOF

Pack them together—bunch them as much as you like—Shakeproof Lock Washers can't link or tangle. Manufacturers are finding that the time saved in this one feature alone oftentimes pays their entire washer bill. Speed up your production line—stop delays—adopt Shakeproof Lock Washers, designed to prevent linking.

MULTIPLE LOCKING

Twisted teeth of steel set around the circumference of the washer. Tighten down the nut and each tooth bites in with a grip of steel—they can't let go. For sure locking demand Shakeproof.

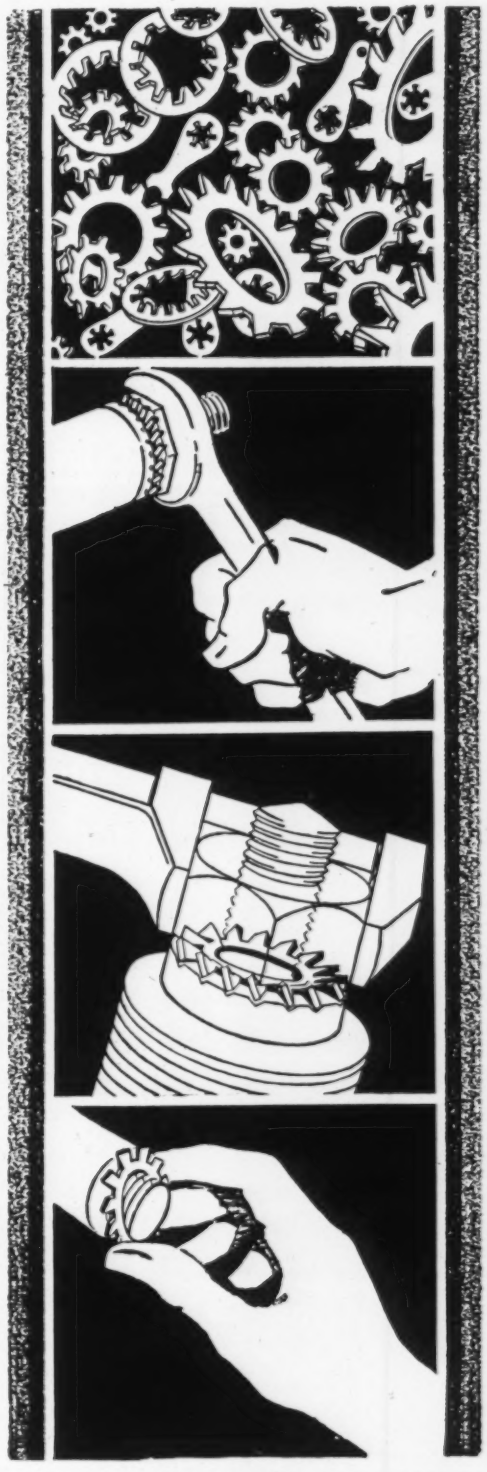
SPREADPROOF

No matter how much pressure is applied you just can't spread a Shakeproof Lock Washer. This eliminates breaking of washers, too, and saves you time and money. With its multiple advantages, it is no wonder that manufacturers, large and small alike, the country over are adopting Shakeproof.

PRODUCTION SPEED

Slip them onto the bolt as fast as the hand can move. Easy to handle—just as easy to apply. Shakeproof will win new friends in your production department and speed up their work for you.

The roll call of American manufacturers is the roll call of Shakeproof users. Pick any car on the road—the radio in your home—the cash register in your neighborhood store—the vacuum cleaner your wife uses—the typewriter on your stenographer's desk—it is a hundred to one they are all locked with Shakeproof.



U.S. Patents, 1,419,564; 1604, 122, 1,697,954. Other Patents Pending. Foreign Patents.

Type 20 Terminal

Type 12 Internal

Type 20 Terminal

FREE SHOP TEST SAMPLES

SHAKEPROOF LOCK WASHER CO.
2511 North Keeler Ave., Chicago, Ill.
Please send me samples of

☐ Shakeproof Locking Terminals Size.....

☐ Shakeproof Lock Washers to fit bolt size.....

Firm Name.....

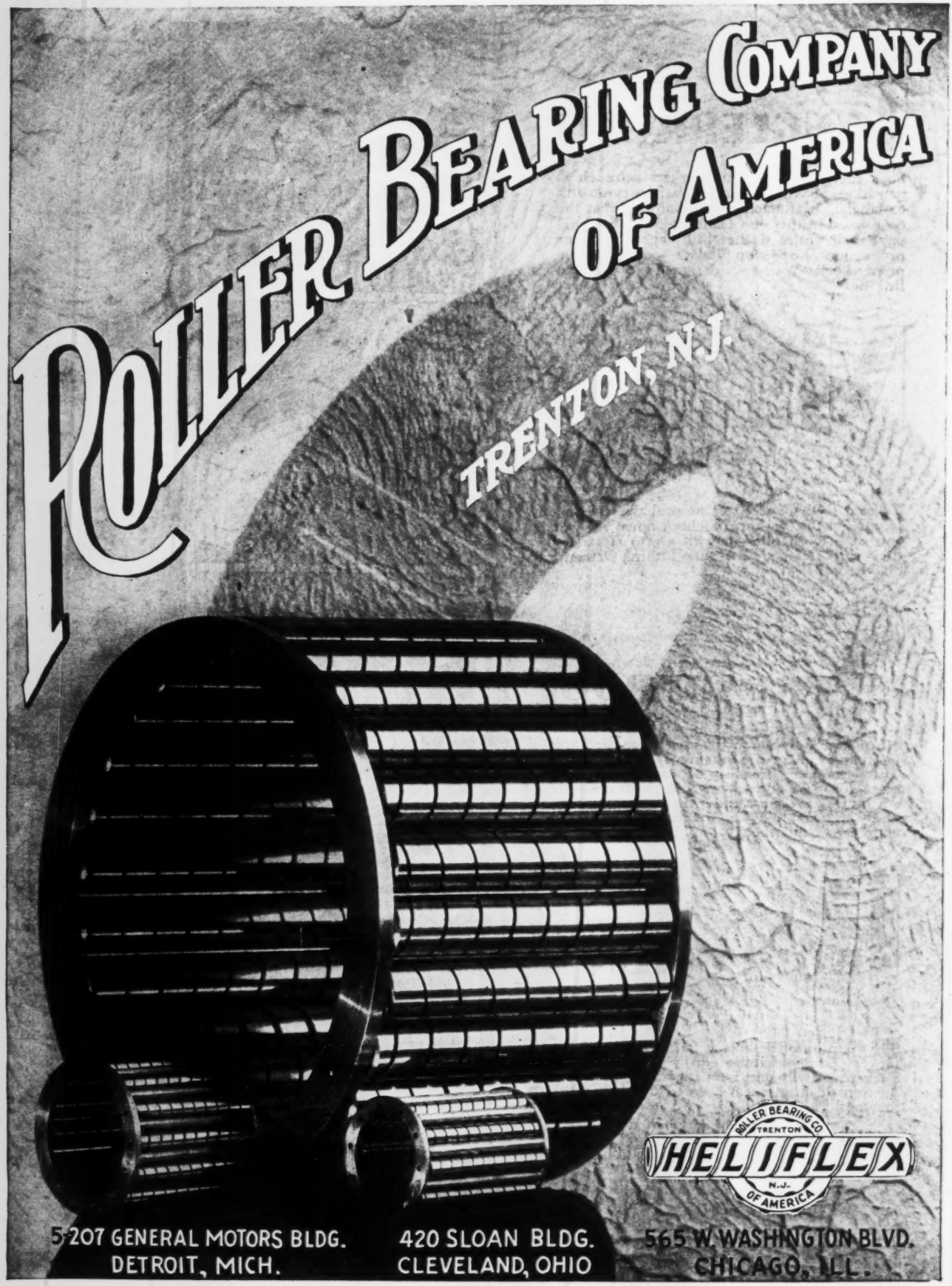
Address.....Town .....

State.....By.....

SHAKEPROOF *Lock Washer Company*

[Division of Illinois Tool Works]

2511 North Keeler Avenue Chicago, Illinois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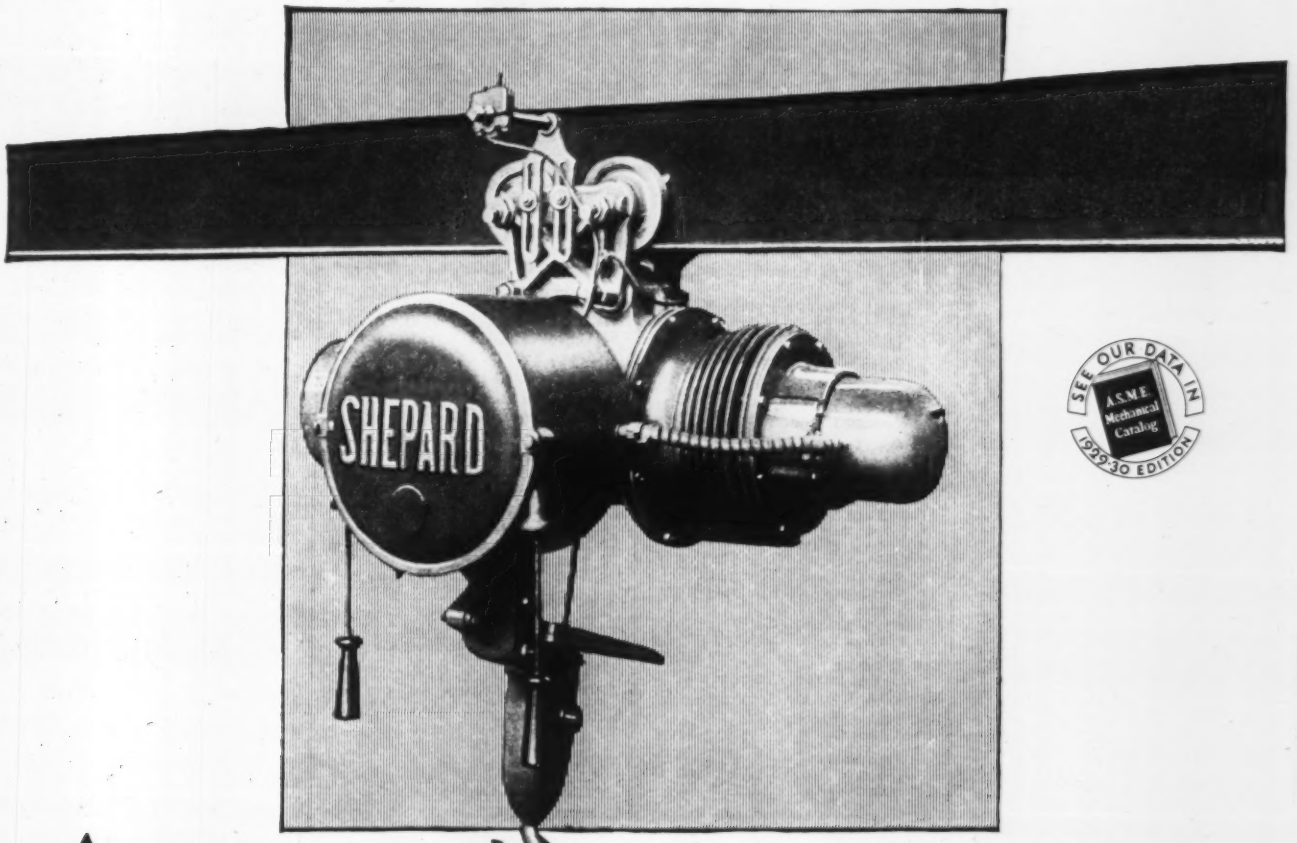
5-207 GENERAL MOTORS BLDG.
DETROIT, MICH.
420 SLOAN BLDG.
CLEVELAND, OHIO
565 W. WASHINGTON BLVD.
CHICAGO, ILL.



SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1929-30 EDITION

Announcing the Shepard Compact Hoist

Consider these features...

1. Sectionalized construction provides a Compact Hoist specially suited to the job... without the cost of special manufacture.
2. Enduring strength is wrought into every detail of the all-steel Shepard Compact Hoist.
3. All moving parts operate in an oil bath, assuring proper lubrication at all times... automatically.
4. Heat treated gears are used in the planetary train.
5. Specially designed motors afford a sure start and a quick stop.
6. Response to controls is instant... positive.

In every detail the Compact Hoist represents the finest that Shepard has produced. It is fortified throughout with the very best of steel... and proportioned to assure the utmost strength per pound of weight.

Safety load block... improved electric brake and limit switch... cooling fins on the load brake... heat treated steel gears... special motor... these are some of the features which Shepard has added to make the new Compact Hoist veritably "a hoist that won't grow old".

Shepard representatives are located in the principal cities from coast to coast. They will be glad to give you complete information.

SHEPARD NILES CRANE & HOIST CORP.
370 Schuyler Ave. Montour Falls, N.Y.
Works: Montour Falls, N.Y., Philadelphia, Pa.

SHEPARD
CRANE & HOIST DIVISION

Member EMA ELECTRIC HOIST MANUFACTURERS ASSOCIATION

Classified List of Mechanical Equipment

Manufactured by Firms Represented in MECHANICAL ENGINEERING

Continued on Pages 34, 36, 38, 40, 42, 44, 46, 48 and 50

Accumulators (Hydraulic)
* Farrel-Birmingham Co. (Inc.)

Aftercoolers (Air)
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Pennsylvania Pump & Compressor Co.
* Sullivan Machinery Co.

Agitators
Columbian Steel Tank Co.

Air Conditioning Apparatus
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Murray, D. J., Mfg. Co.
* Sturtevant, B. F., Co.

Air Cooled Bottoms for Powdered Fuel Furnaces
* Allen-Sherman-Hoff Co.

Air Washers
* Badger, E. B., & Sons Co.
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Murray, D. J., Mfg. Co.
* Sturtevant, B. F., Co.

Alloys
* American Manganese Bronze Co.
* Parker Appliance Co.

Ammeters
* Bristol Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Anemometers
* Taylor Instrument Cos.
Weber, F., Co. (Inc.)

Anchors (Pipe Line)
* National Valve & Mfg. Co.

Annealing
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Arches (Boiler Furnace)
* Combustion Engrg. Corp'n
* McLeod & Henry Co.

Asbestos Products
Carey, Philip, Co.
* Garlock Packing Co.
* Johns-Manville (Inc.)

Ash Handling Systems
* Allen-Sherman-Hoff Co.
* Combustion Engrg. Corp'n
* Link-Belt Co.
* Webster Mfg. Co.

Ash Hoppers (Cast Iron)
* Allen-Sherman-Hoff Co.

Ash Removal Systems
* Allen-Sherman-Hoff Co.

Ash Storage Tanks (Cast Iron)
* Allen-Sherman-Hoff Co.

Babbitt-Metal
* Medart Co.
* Reeves Pulley Co.

Balls (Brass and Bronze)
* Gwilliam Co.

Balls (Cast Iron, Chilled)
* Fuller-Lehigh Co.

Balls (Steel)
* Gwilliam Co.
* Hardinge Co.
* New Departure Mfg. Co.

Barometers
* Consolidated Ashcroft Hancock Co. (Inc.)
* Taylor Instrument Cos.

Barrels (Shop)
* Breese Bros. Co.

Barrels and Boxes (Metal)
Columbian Steel Tank Co.

Bars (Bearing Bronze, Solid and Cored)
* American Manganese Bronze Co.

Bearings (Ball)
* Aetna Ball Bearing Mfg. Co.
* Ahlberg Bearing Co.
* Fafnir Bearing Co.
* Gwilliam Co.
* New Departure Mfg. Co.
* Norma-Hoffmann Bearings Corp'n
* Schatz Mfg. Co.
* Strom Bearings Co.

Bearings (Roller)
* Gwilliam Co.
* Norma-Hoffmann Bearings Corp'n
* Reeves Pulley Co.
* Roller Bearing Co. of America
* Timken Roller Bearing Co.

Bearings (Self-Oiling)
* Jones, W. A., Fdry. & Mach. Co
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Bearings (Tapered Roller)
* Timken Roller Bearing Co.

Bearings (Thrust)
* Aetna Ball Bearing Mfg. Co.
* Ahlberg Bearing Co.
* Fafnir Bearing Co.
* General Electric Co.
* Gwilliam Co.
* New Departure Mfg. Co.
* Norma-Hoffmann Bearings Corp'n
* Schatz Mfg. Co.
* Strom Bearings Co.
* Timken Roller Bearing Co.

Belt Dressing
* Dixon, Joseph, Crucible Co.
Texas Co.

Belt Lacing (Steel)
* Bristol Co.

Belt Tighteners
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Smidth, F. L., & Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Belting (Conveyor, Transmission)
Goodrich, B. F., Rubber Co.
* Webster Mfg. Co.

Bench Legs
* Lupton's, David, Sons Co.

Benders (Tube)
* Parker Appliance Co.

Bending Machines (Hand)
* Parker Appliance Co.

Billets (Steel)
* Timken Roller Bearing Co.

Bins and Shelving (Steel)
* Breese Bros. Co.

Blocks (Cork)
* Armstrong Cork & Insulation Co

Blowers (Centrifugal)
* Allen & Billmyre Co. (Inc.)
* Buffalo Forge Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.
* Wing, L. J., Mfg. Co.

Blowers (Fan)
* Buffalo Forge Co.
* Century Electric Co.
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.
* Wing, L. J., Mfg. Co.

Blowers (Pressure)
* Allen & Billmyre Co. (Inc.)
* Buffalo Forge Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Sturtevant, B. F., Co.
* Wing, L. J., Mfg. Co.

Blowers (Steam Jet)
* Allen & Billmyre Co. (Inc.)
* Schutte & Koerting Co.

Blowers (Turbine)
* Buffalo Forge Co.
* De Laval Steam Turbine Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.
* Wing, L. J., Mfg. Co.

Blueing (Metal)
* American Metal Treatment Co.

Board (Cork)
* Armstrong Cork & Insulation Co.

Boards, Drawing
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Boiler Baffles
* McLeod & Henry Co.

Boiler Compounds
Dearborn Chemical Co.
* Dixon, Joseph, Crucible Co.
Unisol Mfg. Co.

Boiler Feed Water Treatment
Dearborn Chemical Co.

Boiler Fronts
* Erie City Iron Works
* Murray, D. J., Mfg. Co.

Boiler Furnace Construction
* Erie City Iron Works
* Fuller-Lehigh Co.

Boiler Settings (Steel Cased)
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* McLeod & Henry Co.
* Vogt, Henry, Machine Co.

Boilers (Heating)
* Edge Moor Iron Co.
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Leffel, James, & Co.
* Union Iron Works

Boilers (Locomotive)
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Leffel, James, & Co.
* Union Iron Works

Boilers (Marine, Scotch)
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Leffel, James, & Co.

Boilers (Marine, Water Tube)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Connelly, D., Boiler Co.
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Heine Boiler Company
* Springfield Boiler Co.

Boilers (Portable)
* Erie City Iron Works
Frick Co. (Inc.)
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Leffel, James, & Co.
* Union Iron Works

Boilers (Tubular, Horizontal Return)
* Cole, R. D., Mfg. Co.
* Connelly, D., Boiler Co.
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Leffel, James, & Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Tubular, Vertical Fire)
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Leffel, James, & Co.
* Union Iron Works

Boilers (Waste Heat)
* Combustion Engrg. Corp'n
* Edge Moor Iron Co.
* Heine Boiler Company
* Ladd Water Tube Boiler Co.
* Wickes Boiler Co.

Boilers (Water Tube, Horizontal)
* Babcock & Wilcox Co.
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Connelly, D., Boiler Co.
* Edge Moor Iron Co.
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Heine Boiler Company
* Keeler, E., Co.
* Ladd Water Tube Boiler Co.
* Springfield Boiler Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Water Tube, Inclined)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Heine Boiler Company
* Keeler, E., Co.
* Ladd Water Tube Boiler Co.
* Union Iron Works
* Vogt, Henry, Machine Co.
* Wickes Boiler Co.

Boilers (Water Tube, Vertical)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Keeler, E., Co.
* Ladd Water Tube Boiler Co.
* Union Iron Works
* Wickes Boiler Co.

Bolts and Nuts (Self Locking)
* Dardelet Threadlock Corp'n

Boxes (Shelf, Shop, Tote)
* Breese Bros. Co.

Boxes (Tool, Tote)
* Lupton's, David, Sons Co.

Brackets (Pipe)
* Grinnell Co.

Breechings (Smoke)
* Combustion Engrg. Corp'n
* Graver Corp'n
* Murray, D. J., Mfg. Co.
* Vogt, Henry, Machine Co.

Brick (Cork)
* Armstrong Cork & Insulation Co.

Brick (Fire)
* Bernitz Furnace Appliance Co.
* McLeod & Henry Co.

Brick (Insulating)
* Armstrong Cork & Insulation Co.

Bridgewalls (Furnace)
* McLeod & Henry Co.

Bronze (Bearing)
* American Manganese Bronze Co.

Bronze (Roll, Sheet, Etc.)
* American Manganese Bronze Co.

Buckets (Elevator)
* Breese Bros. Co.
* Link-Belt Co.
* Palmer-Bee Co.
* Webster Mfg. Co.

Bunkers (Coal and Ash)
* Allen-Sherman-Hoff Co.
* Webster Mfg. Co.

Burners (Gas and Oil Combined)
* Peabody Engrg. Corp'n

Burners (Oil)
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Peabody Engrg. Corp'n
* Schutte & Koerting Co.

Burners (Powdered Fuel)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Peabody Engrg. Corp'n

Bushings (Bronze)
* American Manganese Bronze Co.
* Murray, D. J., Mfg. Co.
Wood's, T. B., Sons Co.

Cabinets (Blue Print Filing)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Calorimeters
* Consolidated Ashcroft Hancock Co. (Inc.)
* Sarco Co. (Inc.)

Cams
* Hartford Special Machinery Co.

Casehardening
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Casings (Steel, Boiler)
* Hedges-Walsh-Weidner Co.
* Vogt, Henry, Machine Co.

Castings (Acid Resistant)
* American Manganese Bronze Co.
* Bethlehem Steel Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fuller-Lehigh Co.
* Murray, D. J., Mfg. Co.
Walworth Co.

Castings (Aluminum)
* Murray, D. J., Mfg. Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

LUPTON INSPECTION

Before it is shipped from the factory, every Lupton Product must undergo the most rigid examination by a corps of Lupton inspectors. This routine is a part of every job—an assurance that standards of quality and workmanship are constantly maintained.

EMBLAZONED ON THE SKY-LINES OF AMERICA

AGAINST the western sun, the skyline of your city gleams with ruddy reflections from thousands of Lupton Steel Windows. At night, down in the industrial section, the blackness is broken by the scarlet glow of forge and furnace. The windows are again by Lupton.

Whether it be lighting and ventilating systems for factories and mills; fine steel windows for notable office buildings, schools, hotels, apartments, etc.; or whether—out in the suburbs—it be Lupton Residence Casements for private homes . . . every city of size in America is a generous user of Lupton Steel Products.

Indeed, Lupton Steel Windows have the preference among architects and builders generally. Lupton maintains a mechanical laboratory for the express purpose of testing and improving Lupton Steel Products. No Lupton Product is ever released to the public until, over a period of years, it has been proved capable of doing the task for which it was intended.

We do business on the assumption that the future of the Lupton organization goes out with each freight-car from our factory. We do not intend that a reputation of over more than fifty-eight years' standing shall be jeopardized by one inferior job.

Our knowledge of steel windows is an accretion of practical experience. We are in a position to offer advice to responsible contractors, architects and engineers. This service is at your disposal without charge. Write to David Lupton's Sons Company, 2231 E. Allegheny Avenue, Philadelphia, Pa.

The Lupton name is identified with lighting and ventilating successes throughout the country. Listed below are a few of the many manufacturers who use Lupton windows: Ford Motor Company; General Electric Company; International Harvester Corporation; Firestone Tire and Rubber Company; Pullman Company; Dayton-Wright Airplane Company; Remington Arms—U. M. C. Company; American Brass Company; Philadelphia Electric Company.

The Curtiss Flying Service Co., New York, uses Lupton Display Counter advantageously to show flying equipment.

This special Lupton Door frames a colorful and unobstructed picture of a loggia and living terrace.

The Grant Building, forty floors high, is Pittsburgh's largest skyscraper. Lupton Steel Windows are used throughout. Architect, H. Hornbostel. General Contractors, Thompson-Starrett Company.

LUPTON WHERE STEEL IS FUSED WITH SINCERITY

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 190

Castings (Aluminum, Die Cast)
* Parker Appliance Co.

Castings (Brass)
* American Manganese Bronze Co.
* Bethlehem Steel Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Mach'ry Co.
Edward Valve & Mfg. Co.
* Murray, D. J., Mfg. Co.
* Parker Appliance Co.
Walworth Co.

Castings (Bronze)
* American Manganese Bronze Co.
* Bethlehem Steel Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Economy Pumping Mach'ry Co.
Walworth Co.

Castings (Die-Molded)
Veeder-Root (Inc.)

Castings (Heavy)
* Bethlehem Steel Co.
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Fuller-Lehigh Co.
* Murray, D. J., Mfg. Co.
Poole Engrg. & Machine Co.

Castings (Iron)
* Bethlehem Steel Co.
* Builders Iron Foundry
* Cole, R. D., Mfg. Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Mach'ry Co.
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Franklin Machine Co.
* Fuller-Lehigh Co.
* Garlock Packing Co.
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Johnston & Jennings Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Vogt, Henry, Machine Co.
* Webster Mfg. Co.

Castings (Iron, Chilled)
* Fuller-Lehigh Co.

Castings (Monel Metal)
* International Nickel Co. (Inc.)

Castings (Nickel)
* Consolidated Ashcroft Hancock Co. (Inc.)
* International Nickel Co. (Inc.)

Castings (Semi-Steel)
* Builders Iron Foundry
* Croll-Reynolds Engineering Co.
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Castings (Steel)
* Bethlehem Steel Co.
* Falk Corporation
* Link Belt Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Cement (Asbestos)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.
Walworth Co.

Cement (Insulating Heat)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.

Cement (Iron and Steel)
Smooth-On Mfg. Co.

Cement (Pipe Joint)
Smooth-On Mfg. Co.

Cement (Refractory)
* Johns-Manville (Inc.)
* McLeod & Henry Co.

Cement (Water-Resistant)
Smooth-On Mfg. Co.

Centrifugals (Chemical, Sugar)
Tolhurst Machine Works
* Worthington Pump & Mach'ry Corp'n

Centrifugals (Metal Drying)
Tolhurst Machine Works

Chain Belts and Links
* Boston Gear Works Sales Co.
* Diamond Chain & Mfg. Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Morse Chain Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.
* Whitney Mfg. Co.

Chains (Block)
* Boston Gear Works Sales Co.
* Webster Mfg. Co.

Chains and Sprockets (Power Transmission)
* Boston Gear Works Sales Co.
* Diamond Chain & Mfg. Co.
* Link-Belt Co.
* Morse Chain Co.
* Murray, D. J., Mfg. Co.
* Philadelphia Gear Works
* Webster Mfg. Co.
* Whitney Mfg. Co.

Charging Machines (Furnace)
* Shepard Niles Crane & Hoist Corp'n

Chucking Machines
* Jones & Lamson Machine Co.

Chucks (Magnetic)
* General Electric Co.

Chutes
* Breese Bros. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.

Circuit Breakers
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Clamps (Belt)
* Webster Mfg. Co.

Clamps (Pipe and Pipe-Joint)
* Grinnell Co.
* National Valve & Mfg. Co.
Walworth Co.
* Yarnall-Waring Co.

Clarifiers
* Hardinge Co.

Clocks (Engine Room)
* Bristol Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Cloth (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Cloth (Tracing)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Clutches (Friction)
* Allis-Chalmers Mfg. Co.
Brown-Lipe Gear Co.
* Farrel-Birmingham Co. (Inc.)
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Link-Belt Co.
* Philadelphia Gear Works
* Reeves Pulley Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Clutches (Magnetic)
* Magnetic Mfg. Co.

Coal and Ash Handling Machinery
* Combustion Engrg. Corp'n
* Link-Belt Co.
* Palmer-Bee Co.
* Shepard Niles Crane & Hoist Corp'n
* Webster Mfg. Co.

Coal Bins
* Erie City Iron Works
* Link-Belt Co.

Coal Breakers and Cleaners
* Pennsylvania Crusher Co.

Coal Mining Machinery
* General Electric Co.
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.

Coal Tipples
* Fairbanks, Morse & Co.
* Webster Mfg. Co.

Coal Washers
* Hardinge Co.

Coaling Stations (Locomotive)
* Webster Mfg. Co.
* Link-Belt Co.

Coating (Metal Protecting)
* National Valve & Mfg. Co.

Cocks (Air and Gage)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fairbanks Co.
* Jenkins Bros.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
* Nicholson, W. H., & Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Cocks (Blow-Off)
* Crane Co.
* Fairbanks Co.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Coils (Pipe)
* Badger, E. B., & Sons Co.
* Grinnell Co.
* National Valve & Mfg. Co.
* Midwest Piping & Supply Co.
* Superheater Co.
* Vogt, Henry, Machine Co.

Collars (Shaft)
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Coloring (Metal)
* American Metal Treatment Co.

Combustion (CO_2) Recorders
* Brown Instrument Co.
* Permutit Co.
* Republic Flow Meters Co.
* Sarco Co. (Inc.)

Compounds (Cutting; Grinding; Metal Cleaning; Rust Preventing; Grease Removing; Japan and Enamel Removing)
Oakite Products (Inc.)

Compressors (Air)
* Air Preheater Corp'n
* Allen & Billmyre Co. (Inc.)
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Sullivan Machinery Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Compressors (Ammonia)
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Vogt, Henry, Machine Co.
* Worthington Pump & Mach'ry Corp'n

Compressors (Gas)
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Concentrators (Magnetic)
* Magnetic Mfg. Co.

Condensation Return Systems
* Economy Pumping Mach'ry Co.

Condensers (Ammonia)
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Vogt, Henry, Machine Co.

Condensers (Barometric)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Kellogg, M. W., Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Condensers (Jet)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Condensers (Surface)
* Allis-Chalmers Mfg. Co.
Columbian Steel Tank Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Controllers (Condensate)
* Consolidated Ashcroft Hancock Co. (Inc.)

Controllers (Damper)
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Controllers (Electric)
Allen-Bradley Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Controllers (Filter Rate)
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Controllers (Liquid Level)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fisher Governor Co.
* General Electric Co.
* Simplex Valve & Meter Co.

Controllers (Valve, Electrically Operated)
* Bristol Co.
* Brown Instrument Co.

Converters (Electric)
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Conveying Machinery
* Combustion Engrg. Corp'n
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Palmer-Bee Co.
* Shepard Niles Crane & Hoist Corp'n
* Webster Mfg. Co.

Conveying Systems (Pneumatic)
* Allen & Billmyre Co. (Inc.)
* Allington & Curtis Mfg. Co.
* Sturtevant, B. F., Co.

Conveying Systems (Pneumatic Powdered Coal)
* Fuller-Lehigh Co.

Conveying Systems (Steam Jet)
* Allen & Billmyre Co. (Inc.)

Conveyors (Belt)
* Link-Belt Co.
* Webster Mfg. Co.

Conveyors (Bucket, Pan or Apron)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Webster Mfg. Co.

Conveyors (Chain)
* Murray, D. J., Mfg. Co.
* Link-Belt Co.
* Webster Mfg. Co.

Conveyors (Screw)
* Link-Belt Co.
* Webster Mfg. Co.

Cooling Ponds (Spray)
* Badger, E. B., & Sons Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Cooling Towers
* Badger, E. B., & Sons Co.
* Foster Wheeler Corp'n
* Jackson Engineering Corp'n
* Murray, D. J., Mfg. Co.
* Wheeler, C. H., Mfg. Co.

Copper (Drawn)
* Roebling's, John A., Sons Co.

Cork (Granulated and Corkboard)
* Armstrong Cork & Insulation Co.

Counters (Revolution)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Veeder-Root (Inc.)

Countershafts
* Builders Iron Foundry
* Murray, D. J., Mfg. Co.
Wood's, T. B., Sons Co.

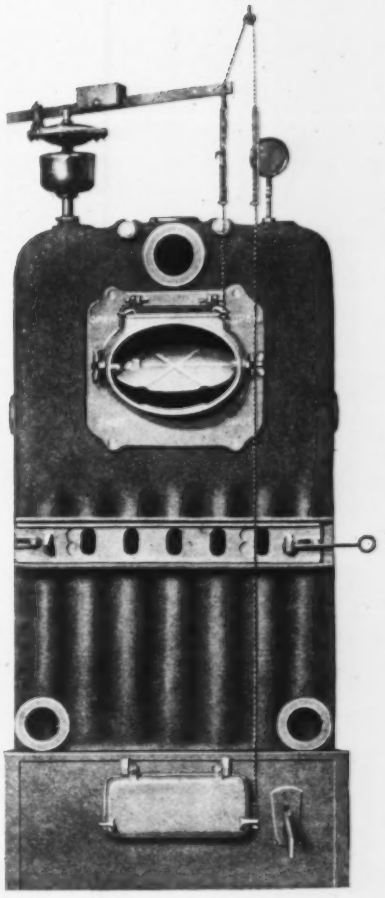
Couplings (Compression)
* Nicholson, W. H., & Co.
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Couplings (Pipe)
* Crane Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.
Walworth Co.

Couplings (Shaft)
* Ajax Flexible Coupling Co.
* Allis-Chalmers Mfg. Co.
* Bartlett Hayward Co.
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Falk Corporation

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

SMITH "16"
FACTS
make sales story easy to put across



Your average customer never bought a boiler before. He knows he wants heating comfort at low cost, but he doesn't know what it is about a boiler that will give it to him. For this very reason you have an opportunity to do a real sales job, telling him about boiler efficiency—which is easy when you have all the efficiency features to talk about that are incorporated in the New Smith "16".

SMITH "16" Sales Features

The New Smith "16" has everything that makes for easy selling and satisfied customers

- Extra Large Fuel Space
- Extra Large Combustion Space
- Fire Pot Lined with Fire Brick
- Auxiliary Air Supply
- Extra Large Fire Surface
- Especially Adapted for Gas and Oil
- Insulated with Air-Cell Jacket

AUXILIARY AIR SUPPLY

Many fuels require more air than can pass through a uniform fuel bed of the thicknesses used in domestic heaters. The U. S. Bureau of Mines says, "As, roughly, one-half of the combustion process takes place in the fuel bed and one-half in the combustion space, the addition of air above the fuel bed for completely burning the gases and preventing smoke is essential. This additional air should be introduced close to the surface of the burning fuel and, if possible, in many fine streams to facilitate its mixing with the combustible gases rising from the fuel bed."

This is perfectly accomplished in the New Smith "16" by a special adjustable slide damper at the rear of the boiler. See illustration above. No matter what fuel is used, the proper amount of air is readily supplied for complete and efficient combustion.

For complete information on this and other efficiency features of the New Smith "16" such as the extra large fuel space, extra large combustion space, firebrick-lined firepot, etc., write for free booklet. "The Smith 16." Address: The H. B. Smith Co., Dept. H-45, Westfield, Mass.

SALES OFFICES AND WAREHOUSES
NEW YORK
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BOSTON
640 Main St., Cambridge
CLEVELAND
1108 Webster Ave., S. E.
WESTFIELD, MASS.

THE H·B·SMITH
BOILERS & RADIATORS
Used in fine homes and buildings since 1860

The H. B. Smith Boilers for steam, hot water and vapor heating; radiators; and hot water supply boilers; for every type and size of private home, office building, factory and public building.

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Alphabetical List on page 190

* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Nicholson, W. H., & Co.
* Nordberg Mfg. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
Smith, T. L., Co.
* Smith & Serrell
* Terry Steam Turbine Co.
* Webster Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
Wood's, T. B. Sons Co.

Couplings (Tubing)
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Couplings (Universal)
* Gears & Forgings (Inc.)
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Coverings (Magnesia)
Carey, Philip, Co.
* Johns-Manville (Inc.)

Coverings (Pipe and Tank)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.
* Johns-Manville (Inc.)

Coverings (Steam Pipe)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.
* Johns-Manville (Inc.)
Walworth Co.

Cranes (Electric Traveling)
* Armington Engineering Co.
* Palmer-Bee Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes (Gantry)
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes (Hand Power)
* Armington Engineering Co.
* Palmer-Bee Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes (Jib)
* Palmer-Bee Co.
* Shepard Niles Crane & Hoist Corp'n

Cranes (Transfer)
* Shepard Niles Crane & Hoist Corp'n

Crucibles (Graphite)
* Dixon, Joseph, Crucible Co.

Crushers (Clinker)
* Farrel-Birmingham Co. (Inc.)

Crushers (Coal)
* Allis-Chalmers Mfg. Co.
* Erie City Iron Works
* Fuller-Lehigh Co.
* Link-Belt Co.
* Pennsylvania Crusher Co.
* Smidth, F. L., & Co.
* Webster Mfg. Co.

Crushers (Hammer)
* Pennsylvania Crusher Co.

Crushers (Jaw)
* Farrel-Birmingham Co. (Inc.)

Crushers (Ore and Rock)
* Farrel-Birmingham Co. (Inc.)
* Fuller-Lehigh Co.
* Nordberg Mfg. Co.
* Pennsylvania Crusher Co.

Crushers (Roll)
* Fuller-Lehigh Co.
* Link-Belt Co.
* Pennsylvania Crusher Co.
* Webster Mfg. Co.

Crushing and Grinding Machinery
* Allis-Chalmers Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Pennsylvania Crusher Co.
* Smidth, F. L., & Co.
* Worthington Pump & Mach'ry Corp'n

Cups (Grease)
* Crane Co.
Gits Bros. Mfg. Co.
Lunkenheimer Co.
Walworth Co.
* Webster Mfg. Co.

Cups (Oil)
* Consolidated Ashcroft Hancock Co. (Inc.)
Gits Bros. Mfg. Co.
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)
Walworth Co.

Cutters (Milling)
* Whitney Mfg. Co.

Cutters (Pipe)
Walworth Co.

Dehumidifying Apparatus
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Sturtevant, B. F., Co.

Desuperheaters
* Superheater Co.

Die Heads (Thread Cutting, Self-opening)
* Jones & Lamson Machine Co.

Dies (Punching and Stamping)
Niagara Machine & Tool Works

Dies (Thread Cutting)
* Jones & Lamson Machine Co.
Walworth Co.

Digesters
* Erie City Iron Works
* Kellogg, M. W., Co.

Distilling Apparatus
* Vogt, Henry, Machine Co.

Doors (Steel, Fire)
* Lupton's, David, Sons Co.

Drafting Room Furniture
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Drawing Inks
Pelican Works—Gunther Wagner (Inc.)

Drawing Instruments and Materials
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Dredging Machinery
* Morris Machine Works

Dryers (Coal)
* Fuller-Lehigh Co.
* Hardinge Co.
* Link-Belt Co.

Drying Apparatus
* Buffalo Forge Co.
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)
* Fuller-Lehigh Co.
* Hardinge Co. (Inc.)
* Kellogg, M. W., Co.
* Link-Belt Co.
* Prat-Daniel Corp'n
* Sturtevant, B. F., Co.

Dust Collecting Apparatus
* Allen & Billmyre Co. (Inc.)
* Allington & Curtis Mfg. Co.
* Allis-Chalmers Mfg. Co.
* Erie City Iron Works
* Hardinge Co.
* Murray, D. J., Mfg. Co.
* Sturtevant, B. F., Co.

Dynamometers
* Consolidated Ashcroft Hancock Co. (Inc.)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.

Economizers, Fuel
* Foster Wheeler Corp'n
* Green Fuel Economizer Co.
* Sturtevant, B. F., Co.

Ejectors
* Chicago Pump Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Schutte & Koerting Co.
* Wheeler, C. H., Mfg. Co.

Ejectors (Steam-Air)
* Worthington Pump & Mach'ry Corp'n

Elevating and Conveying Machinery
* Jones, W. A., Fdry. & Mach. Co.
* Murray, D. J., Mfg. Co.
* Link-Belt Co.
* Palmer-Bee Co.
* Webster Mfg. Co.

Elevators (Electric, Inclined, Portable, Telescopic)
* Link-Belt Co.
* Webster Mfg. Co.

Engine Guards
* Breese Bros. Co.

Engine Repairs
* Franklin Machine Co.
* Murray, D. J., Mfg. Co.
* Nordberg Mfg. Co.

Engine Stops
* Schutte & Koerting Co.

Engines (Gas)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Gasoline)
* Fairbanks, Morse & Co.
* Sturtevant, B. F., Co.

Engines (Hoisting)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Morris Machine Works
* Nordberg Mfg. Co.

Engines (Marine, Oil)
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Marine, Steam)
* Nordberg Mfg. Co.

Engines (Oil)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Fairbanks Morse & Co.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Oil, Diesel)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Fairbanks, Morse & Co.
* Nordberg Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Engines (Steam, Corliss)
* Allis-Chalmers Mfg. Co.
* Franklin Machine Co.
Frick Co. (Inc.)
* Nordberg Mfg. Co.

Engines (Steam, Poppet Valve)
* Erie City Iron Works
* Nordberg Mfg. Co.
* Skinner Engine Co.

Engines (Steam, Throttling)
* Erie City Iron Works
* Skinner Engine
* Troy Engine & Machine Co.

Engines (Steam, Uni-Flow)
* Erie City Iron Works
Frick Co. (Inc.)
* Nordberg Mfg. Co.
* Skinner Engine Co.
* Troy Engine & Machine Co.

Evaporators
* Bartlett Hayward Co.
* Croll-Reynolds Engineering Co.
* Drying Systems (Inc.)
* Farrel-Birmingham Co. (Inc.)
* Foster Wheeler Corp'n
* Murray, D. J., Mfg. Co.
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.

Exhaust Heads
* Kieley & Mueller (Inc.)
* Sturtevant, B. F., Co.
Walworth Co.

Exhaust Systems
* Allen & Billmyre Co.(Inc.)
* Allington & Curtis Mfg. Co.
* Sturtevant, B. F., Co.

Exhausters (Gas)
* Allen & Billmyre Co. (Inc.)
* Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Sturtevant, B. F., Co.
* Wing, L. J., Mfg. Co.

Extractors (Centrifugal)
Tolhurst Machine Works

Extractors (Oil and Grease)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Kieley & Mueller (Inc.)

Fans (Exhaust)
* Allen & Billmyre Co. (Inc.)
* Buffalo Forge Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Murray, D. J., Mfg. Co.
* Prat-Daniel Corp'n
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.
* Wing, L. J., Mfg. Co.

Feeders (Conveyor Belt)
* Webster Mfg. Co.

Feeders (Pulverized Fuel)
* Combustion Engrg. Corp'n
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L., & Co.

Filters (Air)
* Allen & Billmyre Co. (Inc.)
Staynew Filter Corp'n

Filters (Air, Pipe Line)
Staynew Filter Corp'n

Filters (Oil)
* Nugent, Wm. W., & Co. (Inc.
* Permutit Co.

Filters (Water)
* Graver Corp'n
* International Filter Co.
* Murray, D. J., Mfg. Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Filtration Plants (Industrial)
* Graver Corp'n
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Fittings (Ammonia)
* Crane Co.
Frick Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Brass)
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Fittings (Compression)
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)

Fittings (Flanged and Pipe)
* Barco Mfg. Co.
* Builders Iron Foundry
* Crane Co.
Edward Valve & Mfg. Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Hydraulic)
* Crane Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Fittings (Pipe-Brass, Bronze, Steel-Screwed and Flanged)
* American Manganese Bronze Co.
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Fittings (Tank)
* Parker Appliance Co.

Fittings (Tube Compression, Flared or Soldered)
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Flanges
* Crane Co.
Edward Valve & Mfg. Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Taylor Forge & Pipe Works
* Vogt, Henry, Machine Co.
Walworth Co.

Flanges (Forged Steel)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* National Valve & Mfg. Co.
* Taylor Forge & Pipe Works
Walworth Co.

Flexible Shaft Outfits
Strand, N. A., & Co.

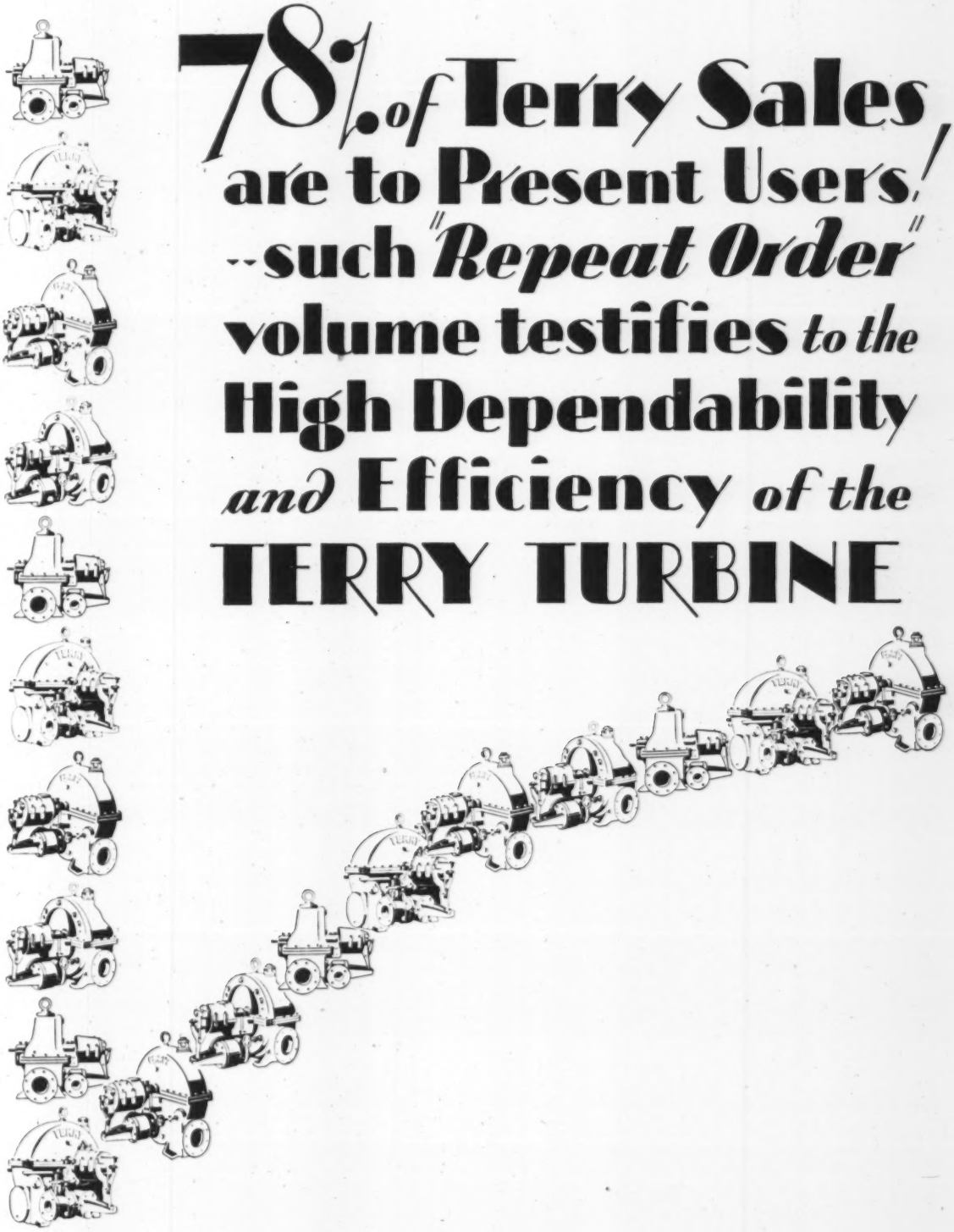
Floats (Copper)
* Nicholson, W. H., & Co.

Floor Stands
* Chapman Valve Mfg. Co.
* Crane Co.
* Grinnell Co.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
* Murray, D. J., Mfg. Co.
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Wood's, T. B., Sons Co.

Flux (Welding)
* Oxweld Acetylene Co.

Fly Wheels
* Medart Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
Wood's, T. B., Sons Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*



78% of Terry Sales are to Present Users! --such "Repeat Order" volume testifies to the High Dependability and Efficiency of the TERRY TURBINE

The Terry Steam Turbine Company

TERRY SQUARE, HARTFORD, CONN.
OFFICES IN PRINCIPAL CITIES

Steam Turbines · Gears · Shaft Couplings

T-1039

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Alphabetical List on page 190

Forges
* Buffalo Forge Co.

Forgings (Bronze)
* American Manganese Bronze Co.

Forgings (Iron and Steel)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Gears & Forgings (Inc.)
* Johnston & Jennings Co.
* Vogt, Henry, Machine Co.

Forgings (Monel Metal)
* International Nickel Co. (Inc.)

Forgings (Nickel)
* Gears & Forgings (Inc.)
* International Nickel Co. (Inc.)

Foundations (Machinery, Cork)
* Armstrong Cork & Insulation Co.
Korfund Co. (Inc.)

Furnaces (Boiler)
* American Engineering Co.
* Babcock & Wilcox Co.
* Bernitz Furnace Appliance Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Taylor Forge & Pipe Works

Furnaces (Boiler, Water-Cooled)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.

Furnaces (Industrial)
* Combustion Engrg. Corp'n
Detroit Electric Furnace Co.
* Erie City Iron Works
* Fuller-Lehigh Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Furnaces (Powdered Coal)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.

Furnaces (Smokeless)
* American Engineering Co.
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works

Gage Boards
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gage Glasses
* Consolidated Ashcroft Hancock Co. (Inc.)
* Jenkins Bros.
Walworth Co.

Gage Testers
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Altitude)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Ammonia)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Vogt, Henry, Machine Co.

Gages (Differential Pressure)
* Bailey Meter Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.

Gages (Draft)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Peabody Engrg. Corp'n
* Republic Flow Meters Co.
* Taylor Instrument Cos.

Gages (Hydraulic)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Liquid Depth)
* Brown Instrument Co.

Gages (Liquid Level)
* Bristol Co.
* Brown Instrument Co.
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Gages (Loss of Head)
* Brown Instrument Co.
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Gages (Measuring, Surface, Depth, Dial, Etc.)
* Norma-Hoffmann Bearings Corp'n

Gages (Pressure)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Gages (Rate of Flow)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Nugent, Wm. W., & Co. (Inc.)
* Simplex Valve & Meter Co.

Gages (Steam)
* Nugent, Wm. W., & Co. (Inc.)

Gages (Vacuum)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Taylor Instrument Cos.

Gages (Water)
* Ashton Valve Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)
Reading Steel Casting Co. (Inc.)
* Simplex Valve & Meter Co.
* Yarnall-Waring Co.

Gages (Water Level)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Lunkenheimer Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Gas (Acetylene)
* Prest-O-Lite Co.

Gaskets
* Garlock Packing Co.
* Jenkins Bros.
* Johns-Manville (Inc.)
* National Valve & Mfg. Co.
* Sarco Co. (Inc.)
Smooth-On Mfg. Co.
Walworth Co.

Gaskets (Copper-Cork)
* Armstrong Cork & Insulation Co.

Gaskets (Copper and Steel)
* Taylor Forge & Pipe Works

Gaskets (Cork)
* Armstrong Cork & Insulation Co.

Gaskets (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Gates (Cut-Off)
* Link-Belt Co.
* Webster Mfg. Co.

Gates (Sluice)
* Allen-Sherman-Hoff Co.
* Chapman Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Murray, D. J., Mfg. Co.

Gear Blanks
* American Manganese Bronze Co.
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Gears & Forgings (Inc.)
* Murray, D. J., Mfg. Co.

Gear Cutting Machines
* Gears & Forgings (Inc.)

Gears (Automobile)
Brown-Lipe Gear Co.

Gears (Bevel)
* Gears & Forgings (Inc.)
* Hartford Special Machinery Co.
* Jones, W. A. Fdry. & Mach. Co.
Poole Engrg. & Machine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Bronze)
* American Manganese Bronze Co.
* Boston Gear Works Sales Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Murray, D. J., Mfg. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Fibre)
* Boston Gear Works Sales Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Helical)
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Herringbone)
* Boston Gear Works Sales Co.
* Falk Corporation
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Machine Molded)
* Farrel-Birmingham Co. (Inc.)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
Poole Engrg. & Machine Co.

Gears (Phenalic Composition)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Ratchet)
* Philadelphia Gear Works

Gears (Rawhide)
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Speed Reduction)
* American Fluid Motors Co.
* Boston Gear Works Sales Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Moore Steam Turbine Corp'n
* Palmer-Bee Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Shepard Niles Crane & Hoist Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Gears (Steel)
* Boston Gear Works Sales Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Gears (Worm)
* American Manganese Bronze Co.
* Boston Gear Works Sales Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* Hartford Special Machinery Co.
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Webster Mfg. Co.
* Westinghouse Elect. & Mfg. Co.

Generating Sets
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Generator Cooling Systems
* Schutte & Koerting Co.

Generators (Acetylene)
* Oxweld Acetylene Co.

Generators (Electric)
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* General Electric Co.
Lincoln Electric Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Governors (Air Compressor)
* Kieley & Mueller (Inc.)
Walworth Co.

Governors (Engine, Oil)
* Nordberg Mfg. Co.

Governors (Engine, Steam)
* Nordberg Mfg. Co.
Walworth Co.

Governors (Oil Burner)
* Fisher Governor Co.

Governors (Oil Operation)
* Kieley & Mueller (Inc.)

Governors (Pump)
Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Squires, C. E., Co.
Walworth Co.

Graphite (Lubricating, Flake)
* Dixon, Joseph, Crucible Co.

Grate Bars
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Murray, D. J., Mfg. Co.
* Vogt, Henry, Machine Co.

Grates (Dumping and Shaking)
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.
* Springfield Boiler Co.
* Vogt, Henry, Machine Co.

Greases
* Dixon, Joseph, Crucible Co.
Texas Co.
Vacuum Oil Co.

Grinding Machines
Strand, N. A., & Co.

Grinding Machines (Floor)
* Builders Iron Foundry

Grinding Machines (Pneumatic, Portable)
* Ingersoll-Rand Co.

Gun Metal Finish
* American Metal Treatment Co.

Hammers (Drop)
* Franklin Machine Co.

Hammers (Pneumatic)
* Ingersoll-Rand Co.

Hangers (Pipe)
* Grinnell Co.
* National Valve & Mfg. Co.

Hangers (Shaft)
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Hardening
* American Metal Treatment Co.

Haulers (Car)
* Link-Belt Co.
* Webster Mfg. Co.

Headers (Welded)
* Grinnell Co.
* Kellogg, M. W., Co.
* Midwest Piping & Supply Co.
* National Valve & Mfg. Co.
Walworth Co.

Heat Exchangers
* Croll-Reynolds Engineering Co.
* Foster Wheeler Corp'n
* Prat-Daniel Corp'n
* Schutte & Koerting Co.
* Superheater Co.
* Wheeler, C. H., Mfg. Co.

Heat Treating
* American Metal Treatment Co.
* Westinghouse Elect. & Mfg. Co.

Heaters (Oil)
* Foster Wheeler Corp'n
* Schutte & Koerting Co.

Heaters (Water Supply, Instantaneous)
* Consolidated Ashcroft Hancock Co. (Inc.)

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

Timken's 8 Ways to Ease Compressor Runs

A Chicago Pneumatic Tool Company Compressor of 500 h. p. offers a fine opportunity for Timken Bearings to prove Timken characteristics. In this one there are 4 Timkens on the crankshaft and 4 on the crankpins.

A compressor so equipped effectively checks power loss, excessive lubrication and rapid depreciation by utilizing the greater thrust, shock and radial load capacity inherently provided by Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS* and Timken-made steel.

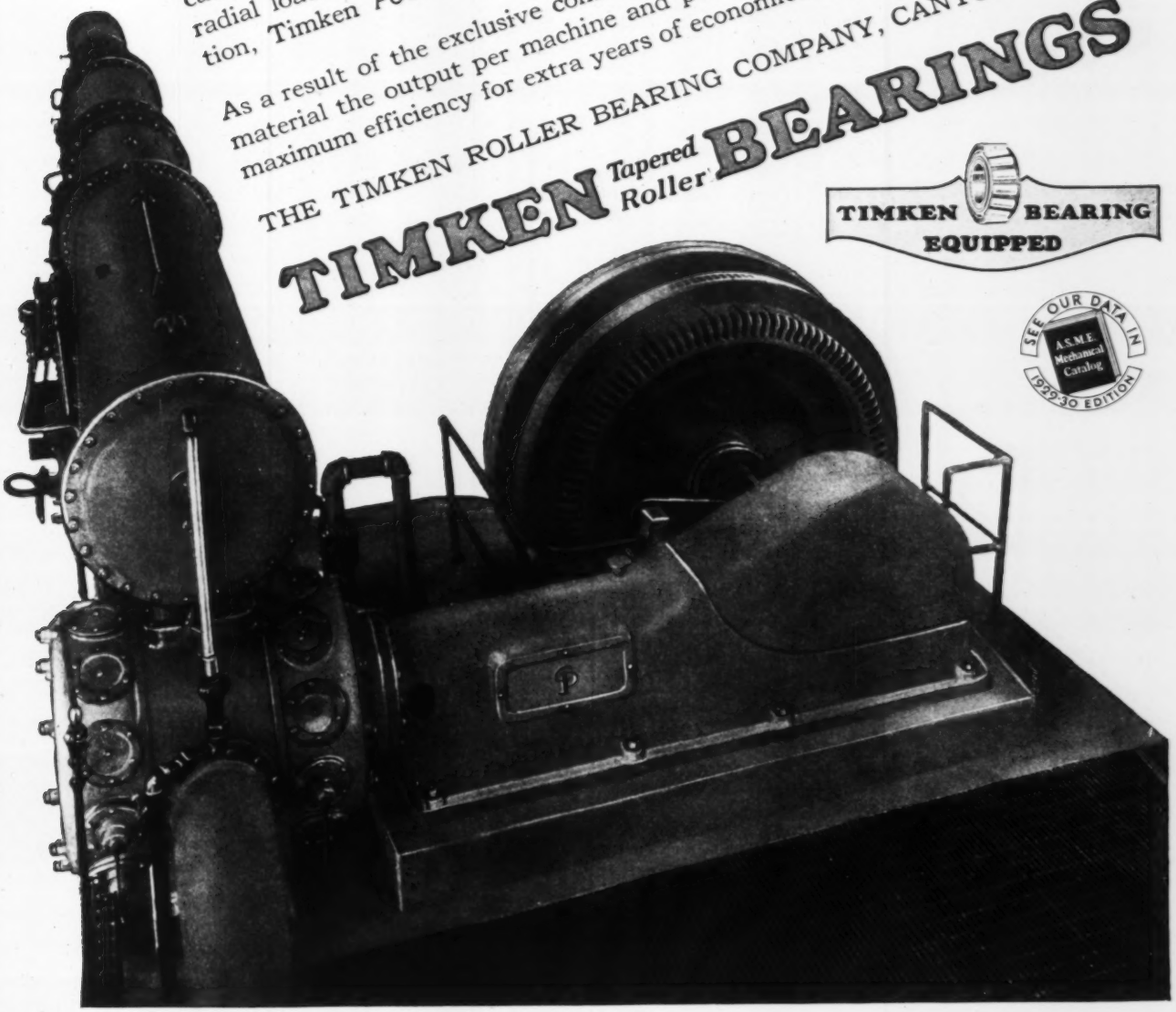
As a result of the exclusive combination of Timken design and Timken material the output per machine and per horse power is maintained at maximum efficiency for extra years of economical operation.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

TIMKEN BEARING EQUIPPED

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1929-30 EDITION



Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

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Heaters and Purifiers (Feed Water)
* Croll-Reynolds Engineering Co.
* Erie City Iron Works
* Foster Wheeler Corp'n
* Hedges-Walsh-Weidner Co.
* Schutte & Koerting Co.
* Springfield Boiler Co
* Wickes Boiler Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Heating Devices (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Heating Specialties
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
* Sarco Co. (Inc.)

Heating Systems
* Buffalo Forge Co.
* Drying Systems (Inc.)
* Grinnell Co.
* Prat-Daniel Corp'n
* Sarco Co. (Inc.)

Heating and Ventilating Apparatus
* Buffalo Forge Co.
* Prat-Daniel Corp'n
* Sturtevant, B. F., Co.
* Wing, L. J., Mfg. Co.

Heating and Ventilating Systems
* Prat-Daniel Corp'n

Hoists (Air)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Palmer-Bee Co.
* Sullivan Machinery Co.

Hoists (Chain)
* Palmer-Bee Co.

Hoists (Electric)
* Allis-Chalmers Mfg. Co.
* American Engineering Co.
* Fairbanks, Morse & Co.
* General Electric Co
* Link-Belt Co.
* Nordberg Mfg. Co.
* Shepard Niles Crane & Hoist Corp'n

Hoists (Gate, Head, Tainter)
* Murray, D. J., Mfg. Co.
* Smith, S. Morgan, Co.

Hoists (Mine)
* Nordberg Mfg. Co.

Hoists (Portable, Electric)
* Sullivan Machinery Co.

Hoists (Skip)
* Link-Belt Co.
* Palmer-Bee Co.
* Webster Mfg. Co.

Hoppers (Coal and Ash)
* Allen-Sherman-Hoff Co.
* Breese Bros. Co.
* Webster Mfg. Co.

Hose
* Fairbanks, Morse & Co.
Goodrich, B. F., Rubber Co.
* Ingersoll-Rand Co.
* Johns-Manville (Inc.)

Humidifiers
* Carrier Engineering Corp'n
* Drying Systems (Inc.)
* Sturtevant, B. F., Co.

Humidity Control
* Brown Instrument Co.
* Carrier Engineering Corp'n
* Sturtevant, B. F., Co.

Hydrants (Fire)
* Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Reading Steel Casting Co. (Inc.)

Hydraulic Press Control Systems (Oil Pressure)
* American Fluid Motors Co.

Hydrokineters
* Schutte & Koerting Co.

Hydrometers
* Taylor Instrument Co.

Hygrometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Taylor Instrument Cos.
Weber, F., Co. (Inc.)

Ice Making Machinery
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Johns-Manville (Inc.)
* Nordberg Mfg. Co.
* Vogt, Henry, Machine Co.

Idlers (Belt)
* Murray, D. J., Mfg. Co.
* Smidth F. L., & Co.,
* Webster Mfg. Co.

Indicator Posts
* Crane Co.
* Grinnell Co.

* Kennedy Valve Mfg. Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Indicator Reducing Motions
* Nugent, Wm. W., & Co. (Inc.)

Indicators (CO, CO_2, SO_2)
* Brown Instrument Co.
* Permutit Co.

Indicators (Draft)
* Brown Instrument Co.
* Republic Flow Meters Co.

Indicators (Engine)
* Consolidated Ashcroft Hancock Co. (Inc.)

Indicators (Liquid Level)
* Brown Instrument Co.
* Fisher Governor Co.

Indicators (Sight Flow)
* Nugent, Wm. W., & Co. (Inc.)

Indicators (Speed)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Veeder-Root (Inc.)

Indicators (Water Line)
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Injectors
* Consolidated Ashcroft Hancock Co. (Inc.)
* Croll-Reynolds Engineering Co.
* Schutte & Koerting Co.

Inspirators
* Consolidated Ashcroft Hancock Co. (Inc.)

Instruments (Electric Measuring)
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.
* Republic Flow Meters Co.
* Taylor Instrument Cos.
* Westinghouse Elect. & Mfg. Co.

Instruments (Hardness Measuring)
Shore Instrument & Mfg. Co.

Instruments (Recording)
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Consolidated Ashcroft Hancock Co. (Inc.)
* General Electric Co.
* Permutit Co.
* Republic Flow Meters Co.
* Taylor Instrument Cos.
* Westinghouse Elect. & Mfg. Co.
* Yarnall-Waring Co.

Instruments (Scientific)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Taylor Instrument Cos.
Weber, F., Co. (Inc.)

Instruments (Surveying)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Insulating Materials (Electrical)
* General Electric Co.
* Johns-Manville (Inc.)
* Westinghouse Elect. & Mfg. Co.

Insulating Materials (Heat and Cold)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.
* Johns-Manville (Inc.)

Insulation (Boiler)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.

Insulation (Heat)
* Armstrong Cork & Insulation Co.
Carey, Philip, Co.

Insulation (Roof and Building)
* Armstrong Cork & Insulation Co.

Jigs and Fixtures
* Parker Appliance Co.

Joints (Expansion)
* Badger, E. B., & Sons Co.
* Barco Mfg. Co.
* Crane Co.
* Croll-Reynolds Engineering Co.
* Foster Wheeler Corp'n
* Grinnell Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Parker Appliance Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.

Joints (Flanged Pipe)
* Barco Mfg. Co.
* Crane Co.
* Midwest Piping & Supply Co.
* National Valve & Mfg. Co.
Walworth Co.

Joints (Flexible)
* Barco Mfg. Co.

Joints (Swing and Swivel)
* Barco Mfg. Co.
Lunkenheimer Co.
Walworth Co.

Joints (Universal)
* Boston Gear Works Sales Co.
* Gears and Forgings (Inc.)
* National Valve & Mfg. Co.

Kettles (Copper)
* Breese Bros. Co.

Kettles (Steam Jacketed)
* Cole, R. D., Mfg. Co.
* Nordberg Mfg. Co.

Keys (Machine)
* Smith & Serrell
* Whitney Mfg. Co.

Larries (Weighing)
* Webster Mfg. Co.

Lathes
* Jones & Lamson Machine Co.

Levers (Flexible, Wire)
* Gwilliam Co.

Linings (Furnace)
* Bernitz Furnace Appliance Co.
* Johns-Manville (Inc.)
* McLeod & Henry Co.

Linings (Stack)
* Johns-Manville (Inc.)

Lock Nuts
Dardelet Threadlock Corp'n

Locomotives (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Locomotives (Oil Engine—Electric Driven)
* Ingersoll-Rand Co.
* Westinghouse Elect. & Mfg. Co.

Locomotives (Storage Battery)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Louvres
* Breese Bros. Co.

Lubricants
* Dixon, Joseph, Crucible Co.
Texas Co.
Vacuum Oil Co.

Lubricating Systems
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)

Lubricators
* Consolidated Ashcroft Hancock Co. (Inc.)
Gits Bros. Mfg. Co.
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Machine Tool Feed Control Systems (Oil Pressure)
* American Fluid Motors Co.

Machine Work
* Builders Iron Foundry
* Farrel-Birmingham Co. (Inc.)
* Franklin Machine Co.
* Hartford Special Machinery Co.
Johnson, Carlyle, Machine Co.
* Johnston & Jennings Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* National Valve & Mfg. Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Roller Bearing Co. of America

Machinery Guards (Perforated Metal)
* Breese Bros. Co.

Magnets (Separating, Suspended)
* Magnetic Mfg. Co.

Manometers
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Mechanical Draft Apparatus
* Air Preheater Corp'n
* Buffalo Forge Co.
* Green Fuel Economizer Co.
* Prat-Daniel Corp'n
* Sturtevant, B. F., Co.

Metal Treating
* American Metal Treatment Co.

Metals (Bearing)
* American Manganese Bronze Co.
* General Electric Co.

Meters (Air and Gas)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.

Meters (Boiler Performance)
* Bailey Meter Co.
* Brown Instrument Co.
* Republic Flow Meters Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Meters (Coal)
* Republic Flow Meters Co.

Meters (Condensation)
* Simplex Valve & Meter Co.

Meters (Electric)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Meters (Feed Water)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Meters (Flow)
* Bailey Meter Co.
* Brown Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Yarnall-Waring Co.

Meters (Gasoline)
* Worthington Pump & Mach'ry Corp'n

Meters (Oil)
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n

Meters (Pitot Tube)
* Brown Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Meters (Steam)
* Bailey Meter Co.
* Brown Instrument Co.
* Builders Iron Foundry
* Republic Flow Meters Co.

Meters (V-Notch)
* Bailey Meter Co.
* Brown Instrument Co.
* Yarnall-Waring Co.

Meters (Venturi)
* Brown Instrument Co.
* Builders Iron Foundry
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

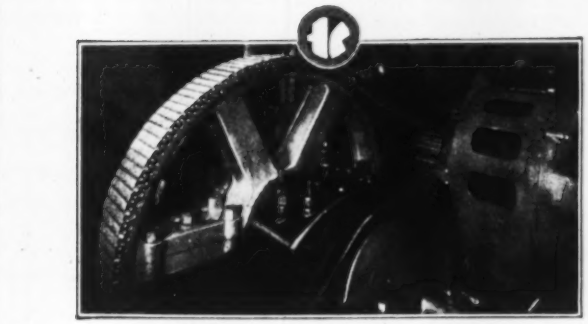
Meters (Water)
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Mach'ry Corp'n
* Yarnall-Waring Co.

Mills (Ball)
* Allis-Chalmers Mfg. Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L., & Co.

Mills (Tube)
* Allis-Chalmers Mfg. Co.
* Smidth, F. L., & Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

Dependable Power with MORSE CHAIN DRIVES



MORSE SILENT CHAINS as installed in the refrigeration plant of The Arena Gardens, Montreal, Canada.

Be sure to see the Morse Chain Co. exhibit at the New York Power Show December 2nd to 7th

For dependability in power transmission, your plant should have Morse Silent Chain Drives. They keep the wheels of industry turning year in and year out, with a minimum of repair and upkeep expense. They transfer your power from the prime mover to the point of use—smoothly, silently, efficiently. The foremost engineers, and the greatest industries of the country choose them because of their proven advantages over any other form of power drive. And once installed in your plant, they will make money for you through lowered overhead, efficient transmission of power, reduced manufacturing costs, and better work done by machines that run at their best.

Morse engineers are always waiting to serve you. A complete file of data on power transmission that is of interest to every business man, every factory maintenance man, and every engineer will be sent you on request. Write for it.

MORSE CHAIN CO.
ITHACA, N. Y.
Branches In Principal Cities

MORSE SILENT CHAIN ←55→ DRIVES

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Alphabetical List on page 190

Mining Machinery
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Webster Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
Worthington Pump & Mach'ry Corp'n

Mixers (Concrete)
Smith, T. L., Co.

Monel Metal
* International Nickel Co. (Inc.)

Motor-Generators
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Motors (Electric)
* Century Electric Co.
* Fairbanks, Morse & Co.
* General Electric Co.
Lincoln Electric Co.
* Shepard Niles Crane & Hoist Corp'n
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Nickel
* International Nickel Co. (Inc.)

Nitrogen Gas
* Linde Air Products Co.

Nozzles (Blast)
* Schutte & Koerting Co.

Nozzles (Boiler)
* Taylor Forge & Pipe Works

Nozzles (Sand and Air)
Lunkenheimer Co.

Nozzles (Spray)
* Badger, E. B., & Sons Co.
* Buffalo Forge Co.
* Grinnell Co.
* Murray, D. J., Mfg. Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Nuts (Lock)
* Dardelet Threadlock Corp'n

Odometers
Veeder-Root (Inc.)

Ohmeters
* General Electric Co.

Oil Burning Equipment
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Schutte & Koerting Co.

Oil Cabinets
* Nugent, Wm. W., & Co. (Inc.)

Oil Refinery Equipment
* Bethlehem Steel Co.
* Foster Wheeler Corp'n
* Graver Corp'n
* Kellogg, M. W., Co.
* Vogt, Henry, Machine Co.
* Wheeler, C. H., Mfg. Co.

Oilers (Line Shaft, from Floor)
* Nugent, Wm. W., & Co. (Inc.)

Oilers (Telescopic)
* Nugent, Wm. W., & Co. (Inc.)

Oiling Devices
Gits Bros. Mfg. Co.
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)

Oiling Systems
Lunkenheimer Co.
* Nugent, Wm. W., & Co. (Inc.)

Oils (Lubricating)
Dearborn Chemical Co.
Lindsay-McMillan Co.
Texas Co.
Vacuum Oil Co.

Ore Concentration Machines
* Hardinge Co.

Ore Handling Machinery
* Link-Belt Co.
* Webster Mfg. Co.

Ovens (Conveyor)
* Drying Systems (Inc.)
* Maehler, Paul, Co.

Ovens (Core)
* Drying Systems (Inc.)
* Maehler, Paul, Co.

Ovens (Enameling, Japanning and Lacquering)
* Drying Systems (Inc.)
* Maehler, Paul, Co.
* Westinghouse Elect. & Mfg. Co.

Ovens (Japanning)
* Breese Bros. Co.
* Drying Systems (Inc.)

Ovens (Sectional)
* Drying Systems (Inc.)
* Maehler, Paul, Co.

Oxy-Acetylene Supplies
* Linde Air Products Co.

Oxygen Gas
* Linde Air Products Co.

Packing (Acid Resisting)
* Crane Packing Co.
* Garlock Packing Co.

Packing (Ammonia)
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Packing (Asbestos)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Johns-Manville (Inc.)
Walworth Co.

Packing (Hydraulic)
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Johns-Manville (Inc.)
* National Valve & Mfg. Co.
Walworth Co.

Packing (Metallic)
* Crane Packing Co.
* Garlock Packing Co.
* Johns-Manville (Inc.)
Walworth Co.

Packing (Metallic Condenser)
* Crane Packing Co.

Packing (Rod, Piston and Valve)
* Crane Packing Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
* Johns-Manville (Inc.)

Packing (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
* Johns-Manville (Inc.)
* National Valve & Mfg. Co.
Walworth Co.

Packing (Sheet)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
* Johns-Manville (Inc.)
* National Valve & Mfg. Co.
Walworth Co.

Paints, Industrial (Casehardening)
Shore Instrument & Mfg. Co.

Paints, Industrial (Concrete, Waterproofing)
Smooth-On Mfg. Co.

Paints, Industrial (Heat Resisting)
* Dixon, Joseph, Crucible Co.
* Johns-Manville (Inc.)

Pans (Copper)
* Breese Bros. Co.

Pans (Machinery)
* Breese Bros. Co.

Paper (Drawing)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Paper (Sensitized)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Paraffin Wax Plant Equipment
* Bethlehem Steel Co.
* Graver Corp'n
* Kellogg, M. W., Co.
* Vogt, Henry, Machine Co.

Partitions (Steel)
* Lupton's, David, Sons Co.

Pawls
* Philadelphia Gear Works

Pencils (Drawing)
* Dixon, Joseph, Crucible Co.
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Penstocks
* Graver Corp'n
* Kellogg, M. W., Co.
* Smith, S. Morgan, Co.
* Taylor Forge & Pipe Works

Pinions (Rolling Mill)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)

Pinions (Steel)
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.

Pins (Air Brake)
Champion Rivet Co.

Pins (Knuckle)
Champion Rivet Co.

Pipe (Brass and Copper)
* Foster Wheeler Corp'n
* National Valve & Mfg. Co.
Walworth Co.

Pipe (Cast Iron)
* Builders Iron Foundry
* National Valve & Mfg. Co.
Walworth Co.

Pipe (Forge Welded)
* Taylor Forge & Pipe Works

Pipe (Riveted)
* Hedges-Walsh-Weidner Co.
* National Valve & Mfg. Co.
* Springfield Boiler Co.
* Taylor Forge & Pipe Works

Pipe (Spiral, Riveted)
* Taylor Forge & Pipe Works

Pipe (Steel)
* Bethlehem Steel Co.
* Crane Co.
* Graver Corp'n
* National Valve & Mfg. Co.

Pipe (Welded)
* Crane Packing Co.
* Grinnell Co.
* National Valve & Mfg. Co.
* Taylor Forge & Pipe Works
Walworth Co.

Pipe (Wrought Iron)
* Crane Co.
* National Valve & Mfg. Co.
Walworth Co.

Pipe Bends
Frick Co. (Inc.)
* Grinnell Co.
* Midwest Piping & Supply Co.
* National Valve & Mfg. Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Pipe Cutting and Threading Machines
* Crane Co.

Piping (Ammonia)
Frick Co. (Inc.)
* Grinnell Co.

Piping (Power)
* Crane Co.
* Grinnell Co.
* Kellogg, M. W., Co.
* Midwest Piping & Supply Co.
* National Valve & Mfg. Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Planimeters
* Bristol Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Plates (Cork, for Machinery Foundations)
Korfund Co. (Inc.)

Plugs (Fusible)
Walworth Co.

Polishing Machines
* Builders Iron Foundry

Powdered Fuel Equipment (for Boiler and Metallurgical Furnaces)
* Allis-Chalmers Mfg. Co.
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L., & Co.

Power Transmission Machinery
* Allis-Chalmers Mfg. Co.
* Diamond Chain & Mfg. Co.
* Farrel-Birmingham Co. (Inc.)
* Foote Bros. Gear & Machine Co.
* Franklin Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Morse Chain Co.
* Murray, D. J., Mfg. Co.
* Palmer-Bee Co.
Poole Engrg. & Machine Co.
* Smidth, F. L., & Co.
* Smith, S. Morgan, Co.
* Webster Mfg. Co.
* Westinghouse Elect. & Mfg. Co.
Wood's, T. B., Sons Co.

Preheaters (Air)
* Air Preheater Corp'n
* Buffalo Forge Co.
* Combustion Engrg. Corp'n
* Edge Moor Iron Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Prat-Daniel Corporation

Presses (Baling)
* Franklin Machine Co.

Presses (Draw)
Niagara Machine & Tool Works

Presses (Extruding)
* Farrel-Birmingham Co. (Inc.)

Presses (Forming)
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Presses (Hydraulic)
* Bethlehem Steel Co.
* Farrel-Birmingham Co. (Inc.)

Presses (Oily Waste and Rags)
* Nugent, Wm. W., & Co. (Inc.)

Presses (Power)
Niagara Machine & Tool Works

Presses (Punching and Trimming)
Niagara Machine & Tool Works

Presses (Toggle)
Niagara Machine & Tool Works

Presses (Wax)
* Vogt, Henry, Machine Co.

Producers (Gas)
* Bartlett Hayward Co.
* Westinghouse Elect. & Mfg. Co.

Pullers (Car)
* Webster Mfg. Co.

Pulleys
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
Johnson, Carlyle, Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Reeves Pulley Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Pulleys (Magnetic)
* Magnetic Mfg. Co.
* Reeves Pulley Co.

Pulverized Fuel Unit Systems
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n
* Fuller-Lehigh Co.

Pulverizers
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fuller-Lehigh Co.
* Hardinge Co.
* Smidth, F. L., & Co.

Pulverizers (Cement Material)
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Pennsylvania Crusher Co.

Pulverizers (Coal)
* Bethlehem Steel Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Foster Wheeler Corp'n
* Fuller-Lehigh Co.
* Hardinge Co.
* Pennsylvania Crusher Co.

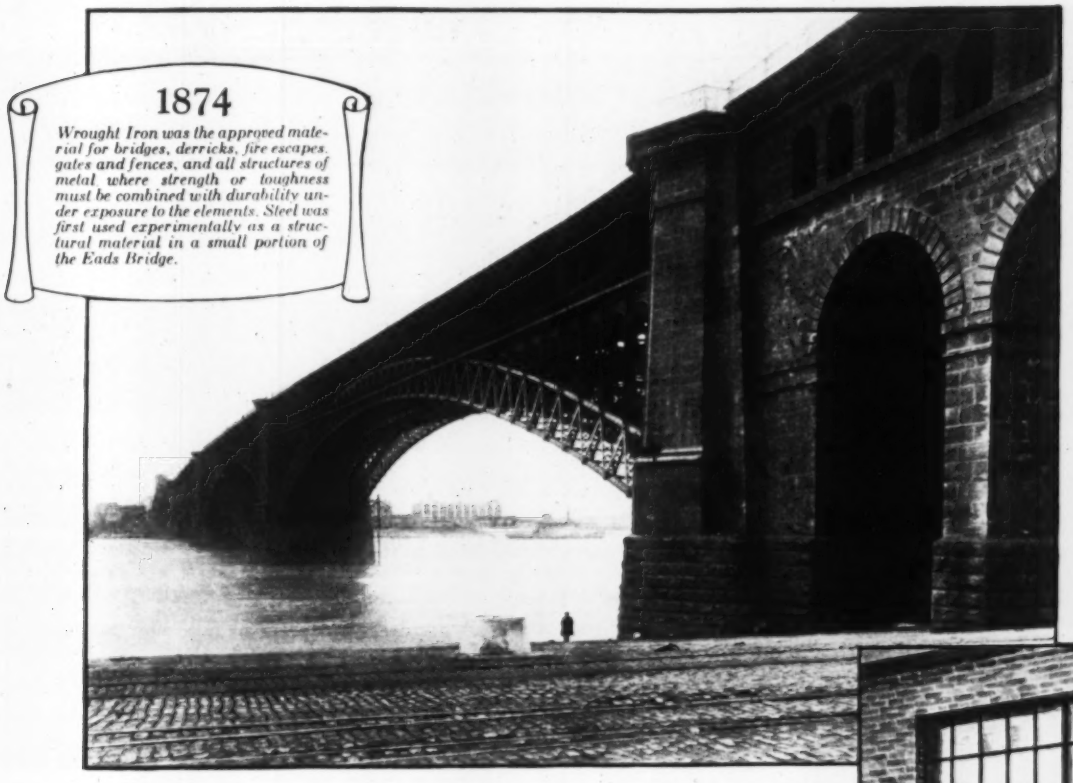
Pulverizers (Limestone)
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.
* Pennsylvania Crusher Co.

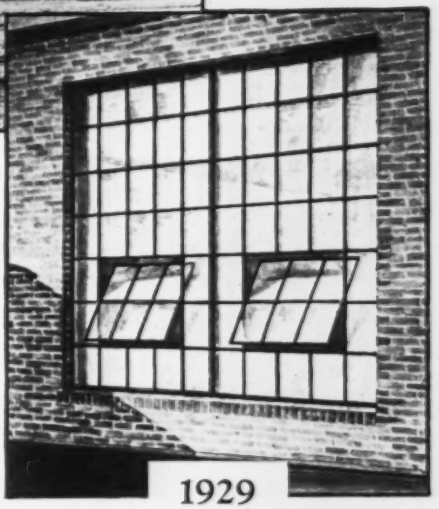
Pulverizers (Refractory Material)
* Bethlehem Steel Co.
* Fuller-Lehigh Co.
* Hardinge Co.

Pulverizers with Air Separators
* Bethlehem Steel Co.
* Erie City Iron Works
* Fuller-Lehigh Co.
* Hardinge Co.

Pumping Outfits
* Pennsylvania Pump & Compressor Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*





Mesker Bros. Iron Co., St. Louis, lately installed 70,000 square feet of wrought iron sash in the Pittsburgh Plate Glass Building, Crystal City, Mo. Engineers and constructors turn to wrought iron for many uses, with a higher and more informed appreciation, since time has enabled them to compare it with newer materials in service. Window Sash is an example.

The Mighty Eads Bridge 55 Years Old

adds its living testimony to the rust-resistance of WROUGHT IRON

THE great bridge that James Buchanan Eads designed to span the Mississippi River at St. Louis was five years in building. It is nearly two thousand feet in length; stone and wrought iron are its principal materials; and it cost six and a half million dollars. Completed in 1874, it was acclaimed as an engineering triumph of the highest order.

After fifty-five years of service, this structure of stone and wrought iron is sound in all its parts and bids fair to last for another half century. It has justified the pride and faith of those who built it, and proved once more the value of materials well chosen.

In bridges and towers, fire escapes, gates and fences, tanks and barges—wherever structural metal is exposed to the elements—wrought iron will be found more economical than metals of lower cost, even though their initial strength be greater. For every year takes toll of their substance, while wrought iron will remain practically unimpaired.

Wrought iron pipe for plumbing, heating, gas, and process materials in industry, will last two to three times longer than ordinary pipe.

In vital parts of locomotives and railway cars, in anchor chains and ship rivets and in other such critical uses where the greatest dependability is required, there has never been a satisfactory substitute for wrought iron.

In ornamental gates and grilles, fences, and furniture, your true craftsman prefers genuine wrought iron because of its ease of welding, its traditional character and the permanence that it assures to his work.

The available forms of wrought iron grow more from time to time. Nails, wire, sheets, fencing, and other fabricated products of wrought iron are again made and used.

For desired information address

WROUGHT IRON RESEARCH ASSOCIATION
1111 Union Bank Building
Pittsburgh, Pa.

Wrought Iron

RUST-RESISTING · SAFE · ENDURING

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 190

Pumping Systems (Air Lift)
* Ingersoll-Rand Co.
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Acid)
* Buffalo Steam Pump Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
* Schutte & Koerting Co.
* Sullivan Machinery Co.
Taber Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Air)
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Sullivan Machinery Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Ammonia)
* Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Pennsylvania Pump & Compressor Co.
* Vogt, Henry, Machine Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Boiler Feed)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* Chicago Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Pennsylvania Pump & Compressor Co.
Westco-Chippewa Pump Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Centrifugal)
* Air Preheater Corp'n
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* Chicago Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Foster Wheeler Corp'n
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Morris Machine Works
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
Taber Pump Co.
Westco-Chippewa Pump Co.
* Westinghouse Elect. & Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Condensation)
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* Chicago Pump Co.
* Economy Pumping Machinery Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Quimby Pump Co. (Inc.)
Westco-Chippewa Pump Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Deep Well)
* Allis-Chalmers Mfg. Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
Westco-Chippewa Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Dredging)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Worthington Pump & Mach'ry Corp'n

Pumps (Fire)
* Buffalo Steam Pump Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Fuel Oil Service)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Hand)
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
Taber Pump Co.

Pumps (Hydraulic)
* American Fluid Motors Co.
* Farrel-Birmingham Co. (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)

Pumps (Hydraulic Pressure)
* Buffalo Steam Pump Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Worthington Pump & Mach'ry Corp'n

Pumps (Mine)
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
Westco-Chippewa Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Oil)
* Nugent, Wm. W., & Co. (Inc.)
* Worthington Pump & Mach'ry Corp'n

Pumps (Oil Pipe Line)
* Worthington Pump & Mach'ry Corp'n

Pumps (Rotary)
* Allen & Billmyre Co. (Inc.)
* Goulds Pumps (Inc.)
* Quimby Pump Co. (Inc.)
* Schutte & Koerting Co.
Taber Pump Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sewage)
* Buffalo Steam Pump Co.
* Chicago Pump Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Worthington Pump & Mach'ry Corp'n

Pumps (Steam)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Fairbanks, Morse & Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Nordberg Mfg. Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sugar House)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Pennsylvania Pump & Compressor Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Sump)
* Buffalo Steam Pump Co.
* Chicago Pump Co.
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Morris Machine Works
* Pennsylvania Pump & Compressor Co.
* Quimby Pump Co. (Inc.)
* Smidth, F. L., & Co.
Taber Pump Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Turbine)
* Allen & Billmyre Co. (Inc.)
* Allis-Chalmers Mfg. Co.
* Buffalo Steam Pump Co.
* Cameron, A. S., Steam Pump Works (Ingersoll-Rand Co.)
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Fairbanks, Morse & Co.
* General Electric Co.
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works)
* Moore Steam Turbine Corp'n
* Morris Machine Works
* Pennsylvania Pump & Compressor Co.
Westco-Chippewa Pump Co.
* Westinghouse Elect. & Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Vacuum)
* Air Preheater Corp'n
* Allen & Billmyre Co. (Inc.)
* Buffalo Steam Pump Co.
* Chicago Pump Co.
* Croll-Reynolds Engineering Co.
* Economy Pumping Mach'ry Co.
* Foster Wheeler Corp'n
* Goulds Pumps (Inc.)
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.
* Pennsylvania Pump & Compressor Co.
* Schutte & Koerting Co.
* Sullivan Machinery Co.
* Wheeler, C. H., Mfg. Co.
* Worthington Pump & Mach'ry Corp'n

Pumps (Vacuum, Steam Jet)
* Foster Wheeler Corp'n

Punches (Power)
* Buffalo Forge Co.
Niagara Machine & Tool Works

Punching and Coping Machines
* Buffalo Forge Co.

Punching and Shearing Machines
* Buffalo Forge Co.
* Schatz Mfg. Co.

Purifiers (Ammonia)
Frick Co. (Inc.)

Purifiers (Feed Water, Boiler)
* Graver Corp'n
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Purifiers (Oil)
* De Laval Steam Turbine Co.
* Nugent, Wm. W., & Co. (Inc.)

Purifying and Softening Systems (Water)
* Graver Corp'n
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Pyrometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Republic Flow Meters Co.
Shore Instrument & Mfg. Co.
* Superheater Co.
* Taylor Instrument Cos.

Racks (Machine Cut)
* Boston Gear Works Sales Co.
* Foote Bros. Gear & Machine Co.
* Horsburgh & Scott Co.
* Jones, W. A., Fdry. & Mach. Co.
* Philadelphia Gear Works
* Westinghouse Elect. & Mfg. Co.

Radiators (Steam and Water)
Smith, H. B., Co.
Walworth Co.

Rams (Hydraulic)
* Goulds Pumps (Inc.)

Receivers (Air)
Columbian Steel Tank Co.
* Foster Wheeler Corp'n
* Hedges-Walsh-Weidner Co.
* Ingersoll-Rand Co.
* Kieley & Mueller (Inc.)
* Worthington Pump & Mach'ry Corp'n

Receivers (Ammonia)
Frick Co. (Inc.)

Refinery Equipment
* Bethlehem Steel Co.
* Graver Corp'n

Refractories
* Bernitz Furnace Appliance Co.
* McLeod & Henry Co.

Refrigerating Machinery
Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Johns-Manville (Inc.)
* Nordberg Mfg. Co.
* Vogt, Henry, Machine Co.

Regulators (Blower)
* Allen & Billmyre Co. (Inc.)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Wing, L. J., Mfg. Co.

Regulators (Compressed Gas)
* Oxweld Acetylene Co.

Regulators (Damper)
* Brown Instrument Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
* Sarco Co. (Inc.)
* Taylor Instrument Cos.
Walworth Co.
* Wing, L. J., Mfg. Co.

Regulators (Electric)
Allen-Bradley Co.
* Brown Instrument Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Regulators (Fan Engine)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
Walworth Co.

Regulators (Feed Water)
* Brown Instrument Co.
Edward Valve & Mfg. Co.
* Kieley & Mueller (Inc.)
* Squires, C. E., Co.

Regulators (Flow Steam)
* Brown Instrument Co.
* Schutte & Koerting Co.

Regulators (Humidity)
* Brown Instrument Co.
* Fulton Sylphon Co.

Regulators (Hydraulic Pressure)
* Fisher Governor Co.

Regulators (Liquid Level)
* Bristol Co.
* Brown Instrument Co.

Regulators (Pressure)
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
* Taylor Instrument Cos.
Walworth Co.

Regulators (Temperature)
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
* Sarco Co. (Inc.)
* Taylor Instrument Cos.

Regulators (Vacuum)
* Allen & Billmyre Co. (Inc.)
* Brown Instrument Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
Walworth Co.

Regulators (Voltage, Automatic)
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Regulators (Water Level)
* Fisher Governor Co.

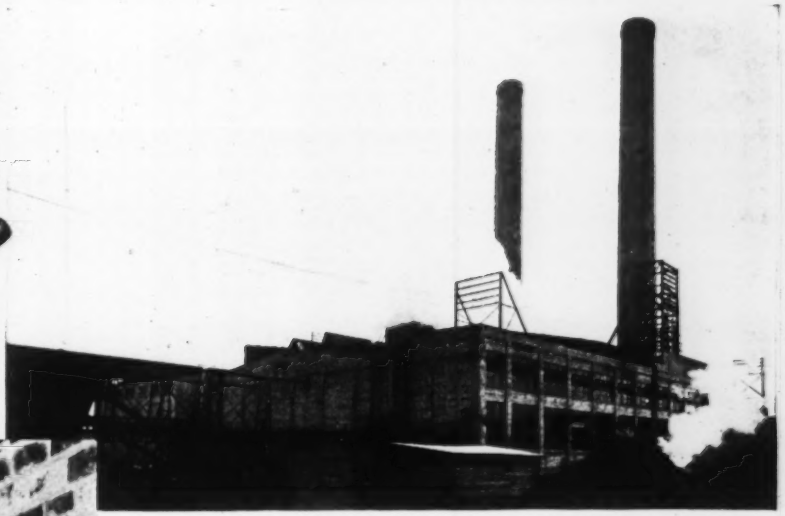
Reheaters
* Superheater Co.

Resuperheaters
* Foster Wheeler Corp'n
* Superheater Co.

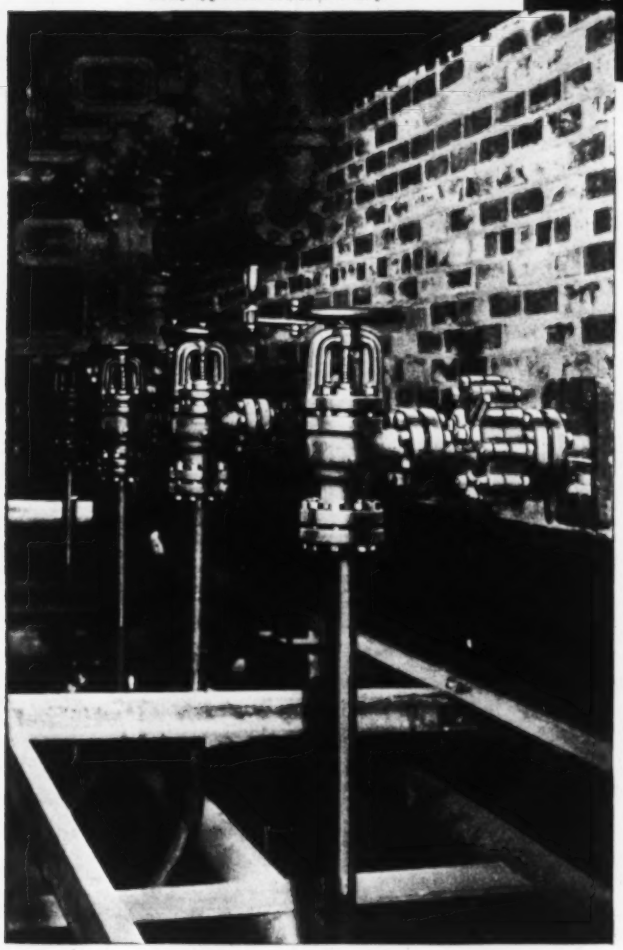
*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

IN THE PLANTS OF THE LEADERS . .

The YARWAY SEATLESS TANDEM BLOW-OFF VALVE (Fig. 3496-88). A popular steel body type for 400 lbs. w .s. p.



Weyerhaeuser Timber Co., Longview, Wash.



YARWAY BLOW-OFF VALVES (Fig. 3486-58) in service at the Weyerhaeuser Timber Co., Longview, Wash.

THE Weyerhaeuser Timber Company is the greatest lumber producing organization in the world. Forest products bearing the Weyerhaeuser "4 Square" trade-mark are known and distributed throughout the United States and in many foreign countries.

32 sets of Yarway cast steel Tandem Blow-Off Valves are in service in the Longview, Washington, plant of this famous producer of lumber, assuring rapid and easy blow-down of the boilers and holding the lines steam-tight at all other times.

In practically every branch of industry requiring steam for the manufacture of the product—paper, lumber, motor cars, electric power, transportation; rubber, metals, oils, textiles—Yarway Blow-Off Valves will be found in the plants of the leaders. For over twenty years they have demonstrated their ability to do a difficult job well.

Yarway Valves are made of cast iron, electric furnace and forged steel in many types and sizes for all pressures to 2000 lbs. Ask for Booklet B-410-C illustrating and describing all types in detail.

YARNALL-WARING COMPANY
Norwood Street Philadelphia

YARWAY BLOW-OFF VALVES

Manufactured by Advertisers — CLASSIFIED LIST OF MECHANICAL EQUIPMENT — Alphabetical List on page 190

Rings (Weldless)
* American Manganese Bronze Co
* Cann & Saul Steel Co.
* Gears & Forgings (Inc.)
* Johnston & Jennings Co.
* Taylor Forge & Pipe Works

Rivet Heaters (Electric)
* General Electric Co.

Riveters (Pneumatic)
* Ingersoll-Rand Co.

Rivets (Boiler and Tank)
Champion Rivet Co.

Rivets (Structural Steel)
Champion Rivet Co.

Rods (Monel Metal)
* International Nickel Co. (Inc.)

Rods (Nickel)
* International Nickel Co. (Inc.)

Rods (Welding)
* Oxweld Acetylene Co.

Rolling Mill Machinery
* Farrel-Birmingham Co. (Inc.)

Rolls (Bending)
Niagara Machine & Tool Works

Rolls (Crushing)
* Farrel-Birmingham Co. (Inc.)
* Fuller-Lehigh Co.
* Link-Belt Co.
* Webster Mfg. Co.

Rolls (Forming, Sheet Metal)
Niagara Machine & Tool Works

Rope (Hoisting)
* Roebling's, John A., Sons Co.

Rope (Transmission)
* Roebling's, John A., Sons Co.
* Link-Belt Co.
* Webster Mfg. Co.

Rope (Wire)
* National Valve & Mfg. Co.
* Roebling's, John A., Sons Co.

Rope Drives
* Allis-Chalmers Mfg. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
Poole Engrg. & Machine Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Rubber Goods (Mechanical)
Goodrich, B. F., Rubber Co.
* Jenkins Bros.

Rules (Measuring, Flexible)
Farrand, Hiram A.

Rust Proofing
Dearborn Chemical Co.
* National Valve & Mfg. Co.

Sash (Steel)
* Lupton's, David, Sons Co.

Sash Operating Systems
* Lupton's, David, Sons Co.

Scales (Automatic, for all Purposes)
* Fairbanks Co.
* Fairbanks, Morse & Co.

Scales (Platform)
* Fairbanks Co.
* Fairbanks, Morse & Co.

Scleroscopes (Hardness Tester)
Shore Instrument & Mfg. Co.

Screens (Revolving)
* Allis-Chalmers Mfg. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Smidth, F. L., & Co.
* Webster Mfg. Co.

Screens (Shaking)
* Allis-Chalmers Mfg. Co.
* Link-Belt Co.
* Webster Mfg. Co.

Screw Driving Machines
Strand, N. A., & Co.

Screw Machines (Hand)
* Jones & Lamson Mach. Co.

Screws (Safety Set)
Allen Mfg. Co.
* Bristol Co.

Screws (Set)
Allen Mfg. Co.

Scrubbers (Air and Gas)
* Bartlett Hayward Co.
* Murray, D. J., Mfg. Co.

Separators (Ammonia)
Frick Co. (Inc.)
* Vogt, Henry, Machine Co.

Separators (Magnetic)
* Magnetic Mfg. Co.

Separators (Oil)
Columbian Steel Tank Co.
* Crane Co.
* Kieley & Mueller (Inc.)
* Nugent, Wm. W., & Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Separators (Steam)
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* National Valve & Mfg. Co.
* Nicholson, W. H., & Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Shafting
* Allis-Chalmers Mfg. Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
Wood's, T. B., Sons Co.

Shafting (Cold Drawn)
* Bethlehem Steel Co.
* Medart Co.
* Webster Mfg. Co.

Shafting (Flexible)
* Gwilliam Co.

Shears (Alligator)
* Farrel-Birmingham Co. (Inc.)

Shears (Rotary)
Niagara Machine & Tool Works

Shears (Squaring)
Niagara Machine & Tool Works

Sheaves (Rope.)
* Jones, W A., Fdry. & Mach. Co.
* Link-Belt Co.
* Medart Co.
* Murray, D. J., Mfg. Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Webster Mfg. Co.
Wood's, T. B., Sons Co.

Sheet Metal Work
* Allington & Curtis Mfg. Co.
* Breese Bros. Co.
Columbian Steel Tank Co.

Sheet Metal Working Machinery
* Farrel-Birmingham Co. (Inc.)
Niagara Machine & Tool Works

Sheets (Monel Metal)
* International Nickel Co. (Inc.)

Sheets (Nickel)
* International Nickel Co. (Inc.)

Sheets (Rubber, Hard)
Goodrich, B. F., Rubber Co.

Sheets (Steel)
* Bethlehem Steel Co.
Columbian Steel Tank Co.

Shelving (Metal)
* Lupton's, David, Sons Co.

Siphons (Steam-Jet)
* Schutte & Koerting Co.

Slide Rules
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Smoke Recorders
* Brown Instrument Co.

Sound Deadening Materials
Korfund Co. (Inc.)

Special Machinery
* Bethlehem Steel Co.
* Builders Iron Foundry
* Farrel-Birmingham Co. (Inc.)
* Franklin Machine Co.
* Gears & Forgings (Inc.)
* Murray, D. J., Mfg. Co.
* Nordberg Mfg. Co.
Poole Engrg. & Machine Co.
* Smidth, F. L., & Co.
* Webster Mfg. Co.

Speed Reducing Transmissions
* American Fluid Motors Co.
Brown-Lipe Gear Co.
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Falk Corporation
* Foote Bros. Gear & Machine Co.
* Gears & Forgings (Inc.)
* General Electric Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Morse Chain Co.
* Palmer-Bee Co.
* Philadelphia Gear Works
Poole Engrg. & Machine Co.
* Shepard Niles Crane & Hoist Corp'n
* Westinghouse Elect. & Mfg. Co.

Spray Cooling Systems
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Sprays (Water)
* Badger, E. B., & Sons Co.
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Sprinkler Systems
* Grinnell Co.

Sprockets
* Boston Gear Works Sales Co.
* Cullman Wheel Co.
* Diamond Chain & Mfg. Co.
* Foote Bros. Gear & Machine Co.
* Fuller-Lehigh Co.
* Link-Belt Co.
* Medart Co.
* Morse Chain Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.

Stacks (Steel)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Prat-Daniel Corp'n
* Union Iron Works
* Vogt, Henry, Machine Co.

Standpipes
* Cole, R. D., Mfg. Co.
* Fairbanks, Morse & Co.
* Graver Corp'n
* Hedges-Walsh-Weidner Co.

Starters (Electric)
Allen-Bradley Co.
* Westinghouse Elect. & Mfg. Co.

Steam Specialties
* Crane Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
* Sarco Co. (Inc.)

Steel (Alloy)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Timken Roller Bearing Co.

Steel (Bar)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Timken Roller Bearing Co.

Steel (Electric Furnace)
* Bethlehem Steel Co.
* Timken Roller Bearing Co.

Steel (Open-Hearth)
* Bethlehem Steel Co.
* Falk Corporation
* Timken Roller Bearing Co.

Steel (Special Analysis)
* Timken Roller Bearing Co.

Steel (Tool)
* Bethlehem Steel Co.
* Cann & Saul Steel Co.
* Timken Roller Bearing Co.

Steel Plate Construction
* Bethlehem Steel Co.
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Keeler, E. Co.
* Union Iron Works
* Vogt, Henry, Machine Co.

Stills
* Bethlehem Steel Co.
* Foster Wheeler Corp'n
* Graver Corp'n
* Kellogg, M. W., Co.
* Vogt, Henry, Machine Co.

Stocks and Dies
Walworth Co.

Stokers (Chain Grate)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Westinghouse Elect. & Mfg. Co.

Stokers (Overfeed)
* Combustion Engrg. Corp'n
* Westinghouse Elect. & Mfg. Co.

Stokers (Traveling Grate)
* Johnston & Jennings Co.

Stokers (Underfeed)
* American Engrg. Co.
* Combustion Engrg. Corp'n
* Sturtevant, B. F., Co.
* Westinghouse Elect. & Mfg. Co.

Strainers (Oil)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Nugent, Wm. W., & Co. (Inc.)
* Sarco Co. (Inc.)
* Schutte & Koerting Co.

Strainers (Steam)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* National Valve & Mfg. Co.
* Sarco Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Strainers (Water)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* National Valve & Mfg. Co.
* Sarco Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Structural Steel Fabrication
* Bethlehem Steel Co.

Structural Steel Work
* Bethlehem Steel Co.
* Erie City Iron Works
* Hedges-Walsh-Weidner Co.

Superheaters (Steam)
* Babcock & Wilcox Co.
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n
* Superheater Co.

Superheaters (Steam, Locomotive)
* Superheater Co.

Superheaters (Steam, Marine)
* Foster Wheeler Corp'n
* Superheater Co.

Switchboards
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Switches (Electric)
Allen-Bradley Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Tables (Drawing)
Keuffel & Esser Co.
Weber, F., Co. (Inc.)

Tachometers
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Veeder-Root (Inc.)

Tachoscopes
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)

Tank Work (Air, Gas, Oil and Water)
* Cole, R. D., Mfg. Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Graver Corp'n

Tanks (Acid)
* Cole, R. D., Mfg. Co.
* Erie City Iron Works
* Graver Corp'n
* Hedges-Walsh-Weidner Co.

Tanks (Ash Storage, Cast Iron)
* Combustion Engrg. Corp'n

Tanks (Blow-Off)
* Erie City Iron Works
* Graver Corp'n

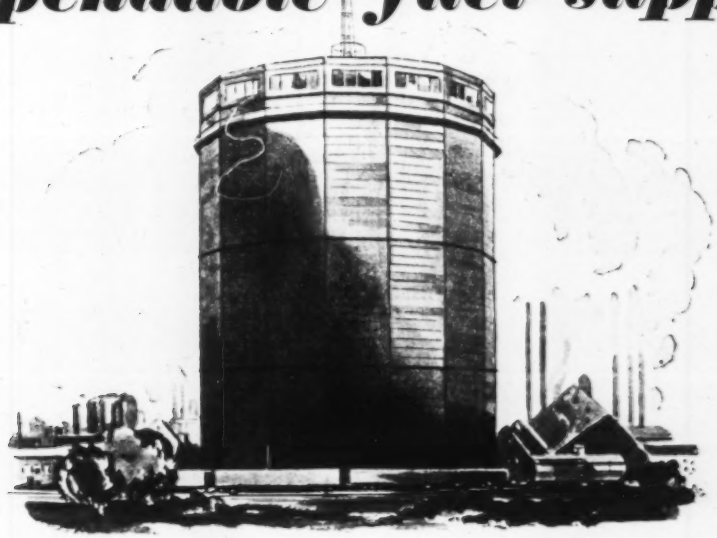
Tanks (Copper)
* Badger, E. B., & Sons Co.
* Breese Bros. Co.

Tanks (Elevated)
* Cole, R. D., Mfg. Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*

GAS

a dependable fuel supply



Today, with the network of intercommunicating gas supply lines, failure of the supply of gas is a very remote possibility. The industrial user of gas is assured of uniform-quality fuel twenty-four hours a day, three hundred and sixty-five days in the year. Can you equal that with any other fuel? ▲ ▲ ▲ ▲ ▲

AMERICAN GAS ASSOCIATION
420 Lexington Avenue, New York

If It's Done With Heat
YOU CAN DO IT BETTER WITH GAS

Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Alphabetical List on page 190

Tanks (Ice)
* Erie City Iron Works
Frick Co. (Inc.)
* Graver Corp'n

Tanks (Oil Storage)
* Nugent, Wm. W., & Co. (Inc.)

Tanks (Pressure)
* Cole, R. D., Mfg. Co.
Columbian Steel Tank Co.
* Erie City Iron Works
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Ingersoll-Rand Co.
* Scaife, Wm. B., & Sons Co.
* Vogt, Henry, Machine Co.

Tanks (Riveted)
* Graver Corp'n

Tanks (Steel)
* Cole, R. D., Mfg. Co.
Columbian Steel Tank Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Union Iron Works
* Vogt, Henry, Machine Co.

Tanks (Storage)
* Allen-Sherman-Hoff Co.
* Cole, R. D., Mfg. Co.
Columbian Steel Tank Co.
* Combustion Engrg. Corp'n
* Erie City Iron Works
* Fairbanks, Morse & Co.
* Graver Corp'n
* Hedges-Walsh-Weidner Co.
* Vogt, Henry, Machine Co.

Tanks (Tower)
* Cole, R. D., Mfg. Co.
* Graver Corp'n
* Hedges-Walsh-Weidner Co.

Tanks (Welded)
* Cole, R. D., Mfg. Co.
Columbian Steel Tank Co.
* Graver Corp'n
* Kellogg, M. W., Co.
* Scaife, Wm. B., & Sons Co.

Tap Extensions
Allen Mfg. Co.

Taps and Dies
Walworth Co.

Thermometers
* Ashton Valve Co.
* Bailey Meter Co.
* Bristol Co.
* Brown Instrument Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
Moto Meter Gauge & Equip. Corp'n
* Sarco Co. (Inc.)
* Taylor Instrument Cos.

Threading Machines (Pipe)
* National Valve & Mfg. Co.

Thermostats
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.
* General Electric Co.

Tile (Cork and Cork Composition)
* Armstrong Cork & Insulation Co.

Tools (Pneumatic)
* Ingersoll-Rand Co.

Tools (Thread Cutting)
* Crane Co.
* Jones & Lamson Machine Co.
Walworth Co.

Torches (Brazing, Carbon Burning, Lead Burning, Etc.)
* Oxweld Acetylene Co.

Torches (Gas)
* Oxweld Acetylene Co.

Trackwork (Industrial)
* Bethlehem Steel Co.

Tracks (Overhead)
* Palmer-Bee Co.

Tractors (Industrial, Gasoline)
Clark Tructractor Co.

Trailers (Industrial)
Clark Tructractor Co.

Tramrail Systems (Overhead)
* Link-Belt Co.
* Shepard Niles Crane & Hoist Corp'n

Tramways (Wire Rope)
* Roebling's, John A., Sons Co.

Transformers (Electric)
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Transmissions (Variable Speed)
* American Fluid Motors Co.
* Foote Bros. Gear & Machine Co.
* Reeves Pulley Co.

Traps (Oil)
* Fisher Governor Co.
* Nicholson, W. H., & Co.

Traps (Radiator)
* Sarco Co. (Inc.)

Traps (Return)
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Sarco Co. (Inc.)

Traps (Steam)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Jenkins Bros.
* Johns-Manville (Inc.)
* Kieley & Mueller (Inc.)
* National Valve & Mfg. Co.
* Nicholson, W. H., & Co.
Reading Steel Casting Co. (Inc.)
* Sarco Co. (Inc.)
* Schutte & Koerting Co.
* Squires, C. E., Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Traps (Vacuum)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* National Valve & Mfg. Co.
* Sarco Co. (Inc.)
* Schutte & Koerting Co.

Trolleys
* Shepard Niles Crane & Hoist Corp'n
* Westinghouse Elect. & Mfg. Co.

Trolleys (Mine Railway including Pantagraphs)
* Westinghouse Elect. & Mfg. Co.

Trolleys (Monorail)
* Armington Engineering Co.
* Palmer-Bee Co.

Trucks (Industrial, Gasoline)
Clark Tructractor Co.

Trucks (Industrial, Storage Battery)
* Fairbanks, Morse & Co.

Trucks (Trailer)
* Fairbanks Co.

Tube Cleaners (Boiler)
Walworth Co.

Tube Flaring Tools
* Parker Appliance Co.

Tubes (Boiler, Charcoal Iron)
* Bethlehem Steel Co.

Tubes (Boiler, Seamless Steel)
* Bethlehem Steel Co.
* Hedges-Walsh-Weidner Co.

Tubes (Condenser)
* Foster Wheeler Corp'n

Tubes (Pitot)
* Brown Instrument Co.
* Republic Flow Meters Co.

Tubing (Aluminum)
* Fulton Sylphon Co.
* Parker Appliance Co.

Tubing (Brass, Bronze and Copper, Seamless)
* Fulton Sylphon Co.
* National Valve & Mfg. Co.
* Parker Appliance Co.
Wolverine Tube Co.

Tubing (Monel Metal)
* Fulton Sylphon Co.
* International Nickel Co. (Inc.)

Tubing (Nickel)
* Fulton Sylphon Co.
* International Nickel Co. (Inc.)

Tubing (Rubber)
Goodrich, B. F., Rubber Co.

Tumbling Barrels
* Erie City Iron Works
* Farrel-Birmingham Co. (Inc.)

Turbines (Hydraulic)
* Allis-Chalmers Mfg. Co.
* Leffel, James, & Co.
* Smith, S. Morgan, Co.

Turbines (Steam)
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.
* Wing, L. J., Mfg. Co.

Turbo-Blowers
* Allen & Billmyre Co. (Inc.)
* General Electric Co.
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Turbine Co.
* Wing, L. J., Mfg. Co.

Turbo-Compressors
* Allen & Billmyre Co. (Inc.)
* De Laval Steam Turbine Co.
* Ingersoll-Rand Co.
* Terry Steam Turbine Co.

Turbo-Generators
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Moore Steam Turbine Corp'n
* Sturtevant, B. F., Co.
* Terry Steam Turbine Co.
* Westinghouse Elect. & Mfg. Co.

Turbo-Pumps
* De Laval Steam Turbine Co.
* Economy Pumping Mach'ry Co.
* Foster Wheeler Corp'n
* Ingersoll-Rand Co.
* Moore Steam Turbine Corp'n
* Terry Steam Turbine Co.

Turntables
* Link-Belt Co.
* Palmer-Bee Co.

Unions
* Crane Co.
Edward Valve & Mfg. Co.
* Fairbanks Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Unloaders (Air Compressor)
* Ingersoll-Rand Co.
* Worthington Pump & Mach'ry Corp'n

Vacuum Breakers
* Allen & Billmyre Co. (Inc.)
* Kieley & Mueller (Inc.)
* Schutte & Koerting Co.

Valve Discs
Edward Valve & Mfg. Co.
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.
* Jenkins Bros.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valve Operating Systems (Electric Remote Control)
* Bristol Co.
* Brown Instrument Co.

Valves (Air, Automatic)
* Allen & Billmyre Co. (Inc.)
* Bristol Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
* Jenkins Bros.
* Simplex Valve & Meter Co.
Smith, H. B., Co.
Walworth Co.

Valves (Air, Operating)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Merco Nordstrom Valve Co.

Valves (Air, Relief)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fulton Sylphon Co.
* Grinnell Co.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.

Valves (Altitude)
* Kieley & Mueller (Inc.)
* Simplex Valve & Meter Co.

Valves (Ammonia)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Jenkins Bros.
* Kieley & Meueller (Inc.)
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
Reading Steel Casting Co. (Inc.)
* Vogt, Henry, Machine Co.
Walworth Co.

Valves (Back Pressure)
* Crane Co.
* Fisher Governor Co.
* Jenkins Bros.
* Kieley & Mueller (Inc.)
* Oxweld Acetylene Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Balanced)
* Brown Instrument Co.
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
* Nordberg Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

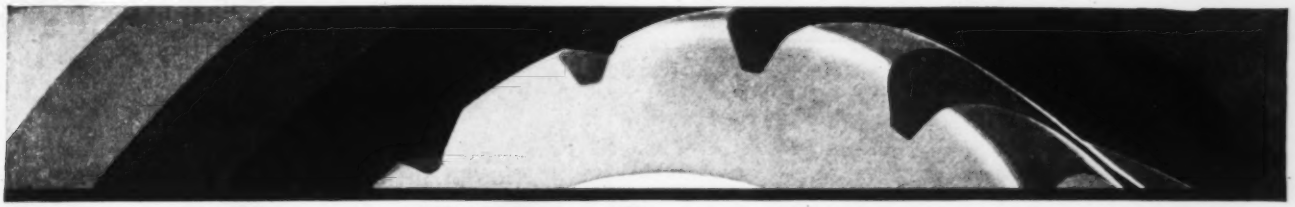
Valves (Blow-off)
* Ashton Valve Co.
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Fairbanks Co.
* Jenkins Bros.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
* Murray, D. J., Mfg. Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.
* Yarnall-Waring Co.

Valves (Butterfly)
* Chapman Valve Mfg. Co.
* Crane Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Schutte & Koerting Co.
Walworth Co.

Valves (By-Pass)
* National Valve & Mfg. Co.

Valves (Check)
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Fairbanks Co.
* Fisher Governor Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Nordberg Mfg. Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Worthington Pump & Mach'ry Corp'n

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*



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IN the gravel industry, too, Horsburgh & Scott Worm-Drive Speed Reducers speed up production . . . weed out exposed gearing and belt and pulley complications.

The plant of the Zanesville Washed Gravel Co., Dresden, Ohio, stands as an example of practical application of this modern drive. Through the processes of conveying, elevating, screening and washing, Horsburgh & Scott Speed Reducers transmit the power reliably and with minimum loss.

Ask our engineering department to give you the benefit of our wide experience in applying gears and speed reducers to your requirements.

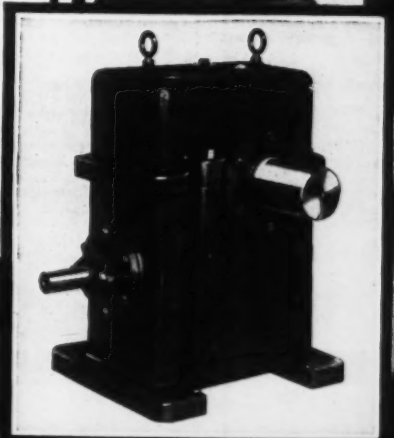
This loose-leaf catalog describes and illustrates the full line of Horsburgh & Scott Speed Reducers, and contains engineering data that will be valuable to you. Write for it.

The Horsburgh & Scott Co.

Gears and Speed Reducers

Cleveland, U. S. A.

Horsburgh & Scott Worm-Gear Speed Reducer driving conveyor in Zanesville Gravel Plant.



Manufactured by Advertisers CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Alphabetical List on page 190

Valves (Chronometer)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
Walworth Co.

Valves (Combined Back Pressure and Relief)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)

Valves (Diaphragm)
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Taylor Instrument Cos.

Valves (Diverting, Pulverized Fuel, Pipe Line)
* Peabody Engrg. Co.

Valves (Electrically Operated)
* Bristol Co.
* Brown Instrument Co.
* Chapman Valve Mfg. Co.
Edward Valve & Mfg. Co.
* Kennedy Valve Mfg. Co.
* Kieley & Mueller (Inc.)
Ludlow Valve Mfg. Co.
Lunkenheimer Co
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.

Valves (Exhaust Relief)
* Crane Co.
Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Foster Wheeler Corp'n
* Jenkins Bros.
* Kieley & Mueller (Inc.)
* Schutte & Koerting Co.
Walworth Co.
* Wheeler, C. H., Mfg. Co.

Valves (Float)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
* Schutte & Koerting Co.
* Simplex Valve & Meter Co.

Valves (Foot)
* Crane Co.
Ludlow Valve Mfg. Co.
* National Valve & Mfg. Co.
Walworth Co.
* Worthington Pump & Mach'ry Corp'n

Valves (Fuel Oil Shut-off)
* Barco Mfg. Co.
* Brown Instrument Co.
* Schutte & Koerting Co.

Valves (Gate)
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fairbanks Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Globe, Angle and Cross)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Fairbanks Co.
* Grinnell Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
* Parker Appliance Co.
* National Valve & Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.

Valves (Hose)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Crane Co.
* Fairbanks Co.
* Grinnell Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valves (Hydraulic)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Fairbanks Co.
Lunkenheimer Co.
* National Valve & Mfg. Co.
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Yarnall-Waring Co.

Valves (Hydraulic Operating)
* Chapman Valve Mfg. Co.
Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Kennedy Valve Mfg. Co
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Yarnall-Waring Co.

Valves (Needle)
* Nugent, Wm. W., & Co. (Inc.)
* Parker Appliance Co.

Valves (Needle Point)
* Nugent, Wm. W., & Co. (Inc.)

Valves (Non-Return)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Jenkins Bros.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Plug)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Fairbanks Co.
* Merco Nordstrom Valve Co.
* Parker Appliance Co.
Reading Steel Casting Co. (Inc.)
Walworth Co.

Valves (Pop Safety)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Lunkenheimer Co.
Walworth Co.

Valves (Pump)
* Garlock Packing Co.
* Goulds Pumps (Inc.)
* Jenkins Bros.
* Johns-Manville (Inc.)
* Nordberg Mfg. Co.

Valves (Radiator)
* Crane Co.
* Fairbanks Co.
* Fulton Sylphon Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
Reading Steel Casting Co. (Inc.)
* Sarco Co. (Inc.)
Walworth Co.

Valves (Radiator, Packless)
* Fulton Sylphon Co.
* Sarco Co. (Inc.)

Valves (Reducing)
* Fisher Governor Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
* Oxweld Acetylene Co.
* Schutte & Koerting Co.
* Squires, C. E., Co.
* Taylor Instrument Cos.
Walworth Co.

Valves (Regulating)
* Bristol Co.
* Brown Instrument Co.
* Crane Co.
* Fisher Governor Co.
* Fulton Sylphon Co.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
* Simplex Valve & Meter Co.
* Taylor Instrument Co.
Walworth Co.

Valves (Relief, Water)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
Walworth Co.

Valves (Safety)
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fisher Governor Co.
* Jenkins Bros.
Lunkenheimer Co.

Valves (Sight Feed)
* Nugent, Wm. W., & Co. (Inc.)

Valves (Sight Flow)
* Nugent, Wm. W., & Co. (Inc.)

Valves (Stop)
* Parker Appliance Co.

Valves (Superheated Steam, Steel)
* Barco Mfg. Co.
* Chapman Valve Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Edward Valve & Mfg. Co.
* Fisher Governor Co.
* Jenkins Bros.
* Kennedy Valve Mfg. Co.
Lunkenheimer Co.
* Merco Nordstrom Valve Co.
* National Valve & Mfg. Co.
* Nordberg Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
* Vogt, Henry, Machine Co.
Walworth Co.
* Yarnall-Waring Co.

Valves (Thermostatically Operated)
* Bristol Co.
* Brown Instrument Co.
* Fulton Sylphon Co.
* Taylor Instrument Cos.

Valves (Throttle)
* Barco Mfg. Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
* Fairbanks Co.
* Jenkins Bros.
Lunkenheimer Co.
* Nordberg Mfg. Co.
Reading Steel Casting Co. (Inc.)
* Schutte & Koerting Co.
Walworth Co.

Valves (Vacuum Heating)
* Kieley & Mueller (Inc.)

Ventilating Systems
* Buffalo Forge Co.

Vibration Isolation Materials
Korfund Co. (Inc.)

Vises (Machine Tool)
* Hartford Special Machinery Co.

Voltmeters
* Bristol Co.
* Brown Instrument Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Washers (Hardened and Ground)
* Aetna Ball Bearing Mfg. Co.

Washers (Lock)
* Shakeproof Lock Washer Co.

Washers (Rubber)
* Garlock Packing Co.
Goodrich, B. F., Rubber Co.

Washers (Thrust)
* Aetna Ball Bearing Mfg. Co.
* Boston Gear Works Sales Co.

Waste Heat Recovery Systems
* Edge Moor Iron Co.

Water Columns
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Kieley & Mueller (Inc.)
Lunkenheimer Co.
* Yarnall-Waring Co.

Water Purifying Plants
* Graver Corp'n
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Water Softeners
* Graver Corp'n
* International Filter Co.
* Permutit Co.
* Scaife, Wm. B., & Sons Co.

Water Walls (Furnace)
* Combustion Engrg. Corp'n
* Edge Moor Iron Co.
* Foster Wheeler Corp'n
* Fuller-Lehigh Co.
* Springfield Boiler Co.
* Superheater Co.

Waterbacks (Furnace)
* Combustion Engrg. Corp'n
* Foster Wheeler Corp'n

Waterproofing Materials
Carey, Philip, Co.
* Johns-Manville (Inc.)
Texas Co.

Wattmeters
* Bristol Co.
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Welding (Hammer Forge)
* Kellogg, M. W., Co.

Welding and Cutting Work
* Linde Air Products Co.

Welding Equipment (Electric)
* General Electric Co.
Lincoln Electric Co.
* Westinghouse Elect. & Mfg. Co.

Welding Equipment (Oxy-Acetylene)
* Linde Air Products Co.
* Oxweld Acetylene Co.

Wheels (Trolley and Crane Track)
* Westinghouse Elect. & Mfg. Co.

Wheels (Truck, Factory)
* Fairbanks Co.

Whistles (Steam)
* Ashton Valve Co.
* Consolidated Ashcroft Hancock Co. (Inc.)
* Crane Co.
Lunkenheimer Co.

Winches
* Ingersoll-Rand Co.
* Shepard Niles Crane & Hoist Corp'n

Windows (Steel, Industrial)
* Lupton's, David, Sons Co.

Wire (Brass and Copper)
* Roebling's, John A., Sons Co.

Wire (Flat)
* Roebling's, John A., Sons Co.

Wire (Iron and Steel)
* Bethlehem Steel Co.
* Roebling's, John A., Sons Co.

Wire (Welding)
Lincoln Electric Co.
* Oxweld Acetylene Co.

Wire and Cables (Electrical)
* General Electric Co.
* Roebling's, John A., Sons Co.

Wire Mechanism (Bowden Wire)
* Gwilliam Co.

Wire Rope Fastenings
* Roebling's, John A., Sons Co.

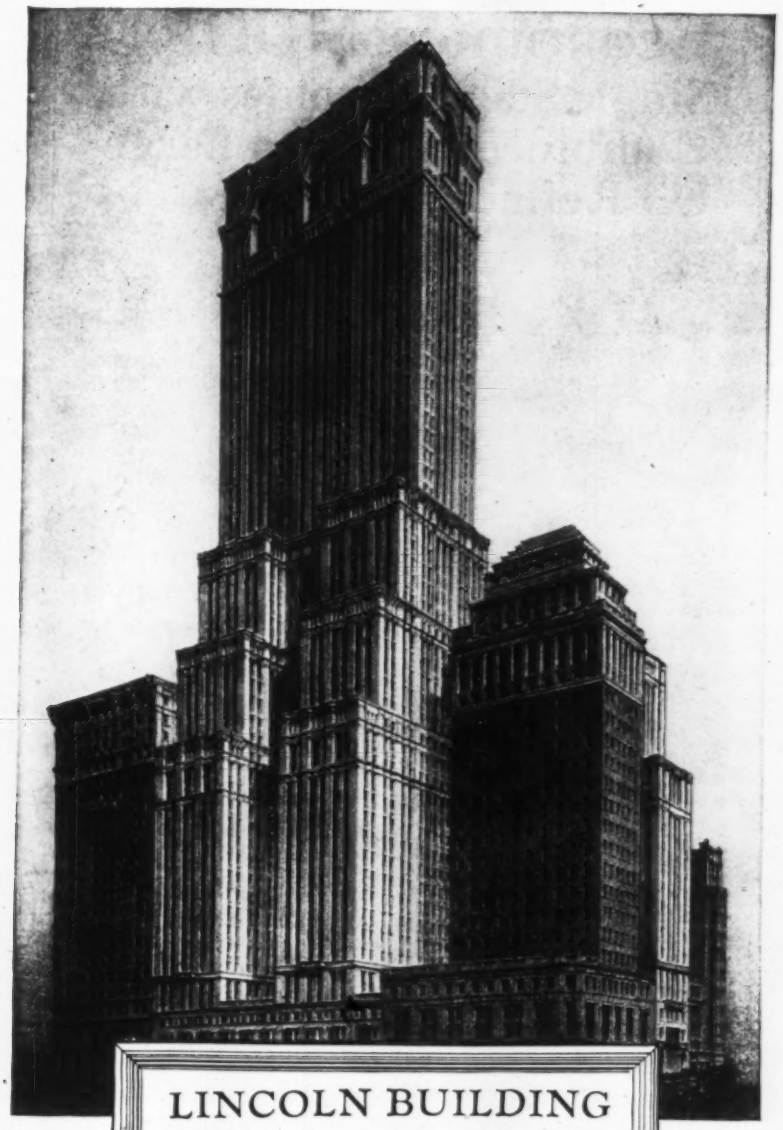
Wire Rope Slings
* Roebling's, John A., Sons Co.

Wiring Devices
* General Electric Co.
* Westinghouse Elect. & Mfg. Co.

Worm Gear Drives
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* Foote Bros. Gear & Machine Co.
* Jones, W. A., Fdry. & Mach. Co.
* Link-Belt Co.
* Murray, D. J., Mfg. Co.
* Webster Mfg. Co.

Wrenches
* Roebling's, John A., Sons Co.
Walworth Co.

*Catalog data of firms marked * appear in the A.S.M.E. Mechanical Catalog, 1929–30 Edition*



LINCOLN BUILDING

BRASS VALVES STEEL VALVES
IRON BODY VALVES
HOSE VALVES
IRON BRASS FITTINGS
BY WALWORTH

42nd and MADISON AVE.

Another WALWORTH JOB

The Lincoln Building, with frontage on 42nd Street, 41st Street and Madison Avenue, New York, presents to millions of arrivals at Grand Central Station and to the multitudes who pass down Vanderbilt Avenue each day one of the most magnificent views of modern building achievement in the world. The builders, Dwight P. Robinson & Company, specified Walworth material for this latest and finest addition to New York's skyline. Of particular interest is the fire protection system. The building is so high that proper working pressure at the topmost hose outlet presented a difficult problem to the engineers. Walworth Sigma Steel valves and extra heavy fire line fittings solved the difficulty. The regular city water pressure is supplemented by fire pumps and engines.

For the major building jobs throughout America, architects, engineers and plumbing and heating contractors are coming more and more to specify Walworth, because Walworth makes a complete line of brass, iron body and steel valves and fittings — with higher engineering excellence and quality of material the constant goal.

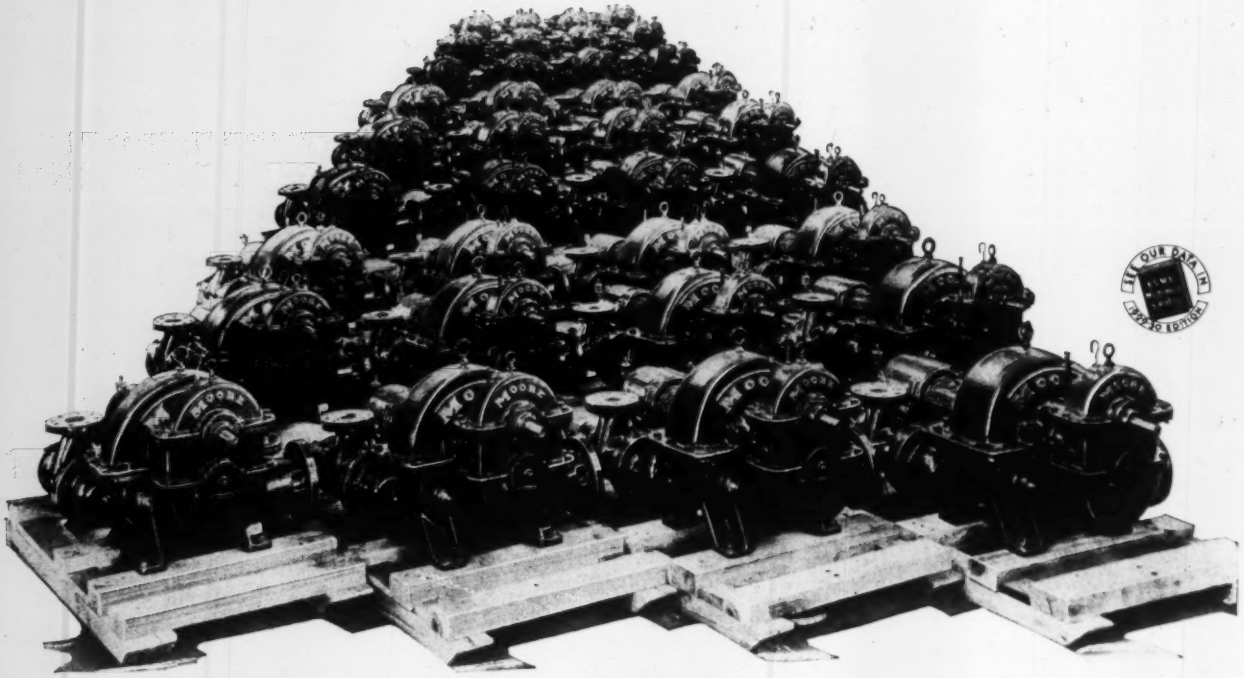
Dwight P. Robinson & Company, Incorporated
Builders
J. E. R. Carpenter, Architect
E. J. Willingale Kenneth B. Norton
William Harmon Beers
Associate Architects
Clyde R. Place, Consulting Mechanical Engineer
J. L. Murphy, Inc.—Plumbing Contractor
Baker Smith & Company—Heating Contractor

WALWORTH

Walworth Company, General Sales Offices: 51 E. 42nd St., New York
Plants at Boston, Mass.; Kewanee, Ill.; Greensburg, Pa.; and Attalla, Ala.
. . . Distributors in Principal Cities of the World . . .

60

Economical MOORE Single Stage Turbines with Combined Gear in a Large Oil Refinery—



36 of the 60

Established Ideal Balance Between
Available Exhaust and Process Steam Required

The much lower steam consumption by these efficient MOORE geared turbine units for driving oil pumps at a moderate speed enabled this plant to operate at maximum economy.

If direct connected turbines had been purchased at a slightly lower initial cost, the operation would have resulted in a surplus in exhaust steam, representing a direct fuel waste. The cost for power and the necessity of generating steam for processing, likewise would have made the installation of electrical motor drives uneconomical.

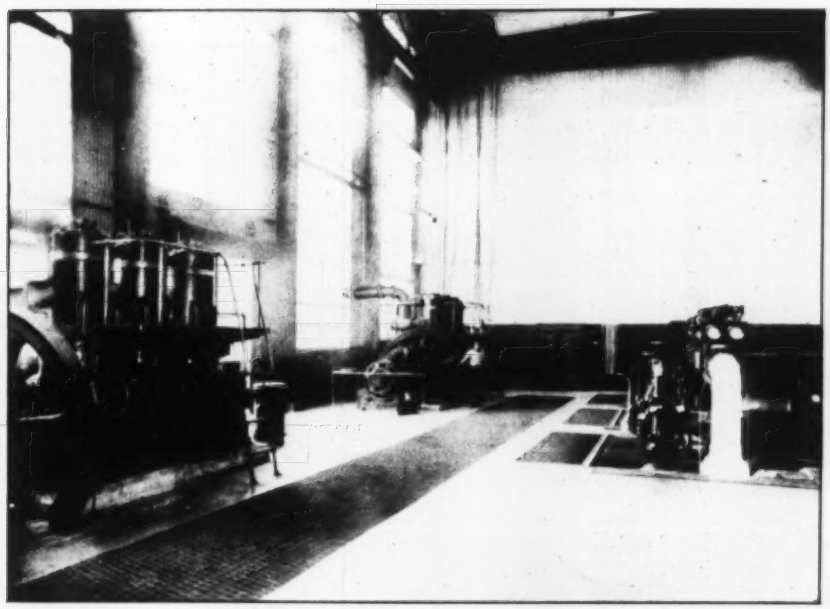
The high efficiency and compactness of MOORE Single Stage Turbines with Combined Reduction Gear adapts them to economically drive power plant auxiliaries and many types of moderate speed factory drives in all plants in which a limited amount of exhaust steam can be used for heating or processing.

Write for descriptive bulletin.

Moore Steam Turbine Corporation
Wellsville, N. Y.

STEAM TURBINES **REDUCTION GEARS** **CENTRIFUGAL PUMPS**

Largest Philippine sugar mill uses F-M Diesels



Two 180 hp. F-M Diesel Generating Sets handle plant load in off-season periods

The Central Tarlac Mill, with a daily capacity of approximately 350 tons, is the largest sugar mill in the Philippines. In keeping with the general practice of the sugar industry, this mill has a steam plant for its main source of power—using its waste products (bagasse) for fuel. However, important savings are accomplished by F-M Diesels.

During the off season period when production is at a minimum, current is required for operating the miscellaneous equipment which is used during the "clean-up" and maintenance service periods. The comparatively light load during these seasons makes operation of the turbo-generators uneconomical. Therefore, two 180 hp. F-M Diesel alternator sets were installed.

The instantaneous starting characteristics of these F-M units make them ideal stand-by equipment. In addition, they use no fuel when idle. In contrast, if steam equipment had been installed for this service it would have been necessary to maintain boiler pressure 24 hours a day, even though the night load during the off-season is extremely low.

Simple construction, ease of operation and absolute reliability are features of this F-M Diesel installation that are praised highly by the superintendent of the Central Tarlac Mill. These characteristics will be found in *every* F-M Diesel installation. F-M power specialists are available for consultation without obligation to you.

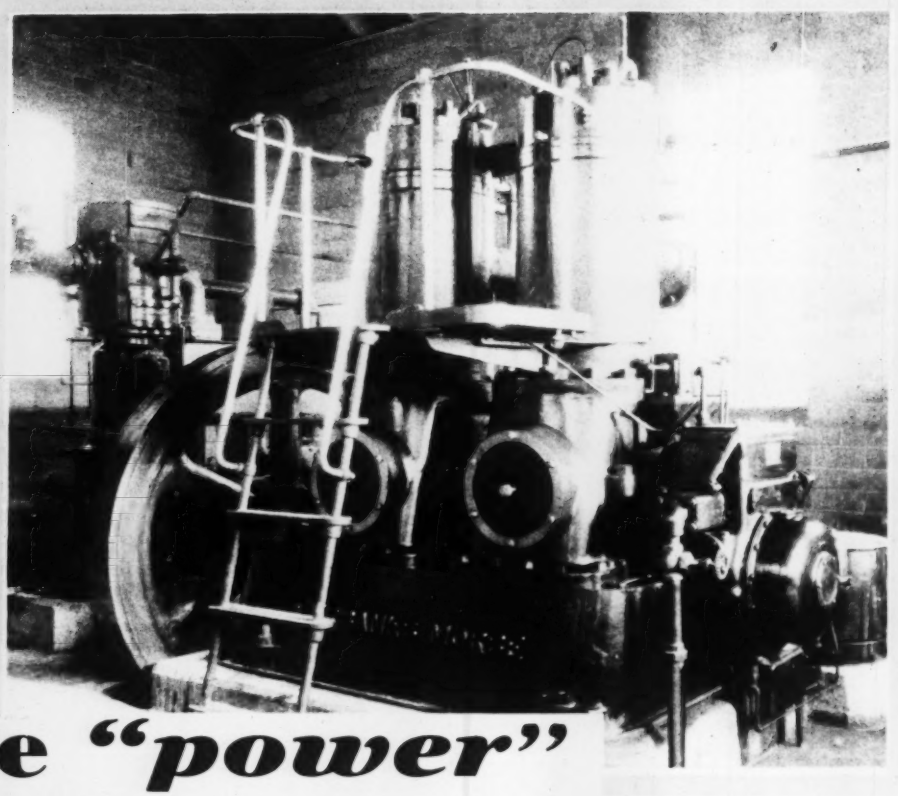
FAIRBANKS-MORSE

DIESEL ENGINES

POWER, PUMPING AND WEIGHING EQUIPMENT

FAIRBANKS-MORSE DIESEL ENGINES

FAIRBANKS-MORSE DIESEL ENGINES



F-M Diesels are built in a variety of sizes from 25 hp. to 980 hp.

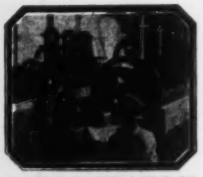
he "power" to cut costs . . .

Fairbanks-Morse research and development have made available to industry the "power" to cut costs.

They have perfected a simple, high over-all economy type of Diesel that is setting new, low-power costs within the field of Diesel power generation.

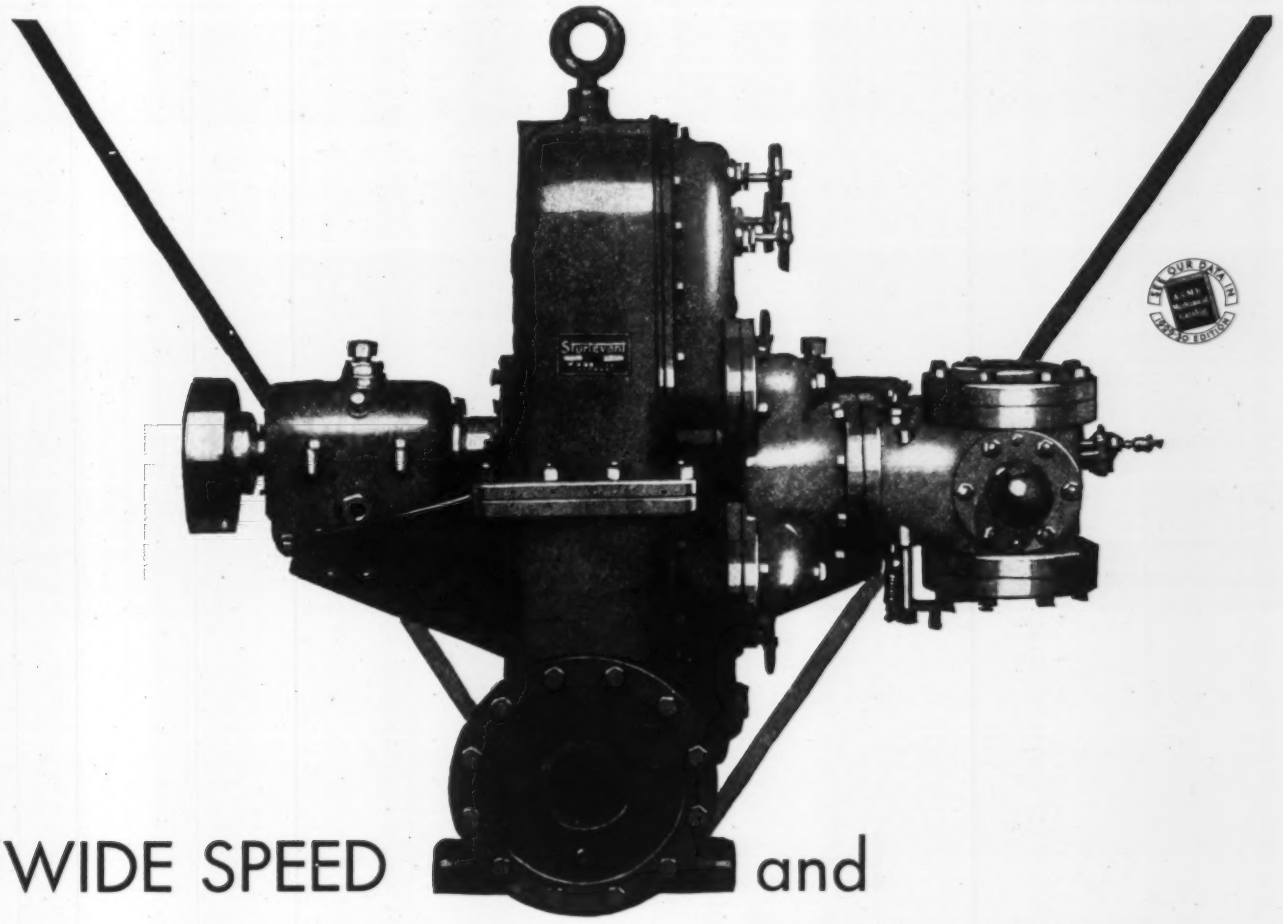
In addition to the ordinary high economies of the Diesel, Fairbanks-Morse two cycle, airless injection engines have the added feature of extremely low maintenance. The result is a prime mover that will cut costs in most industries where even lower than average costs now apply.

FAIRBANKS, MORSE & CO., *Chicago*
32 branches at your service throughout the United States

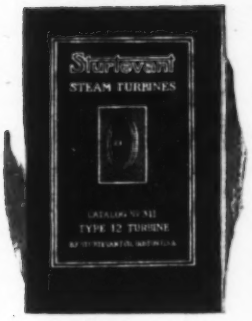


FAIRBANKS-MORSE

OA 97.20



WIDE SPEED and LOAD RANGE



THIS particular Sturtevant Turbine (Type 12) specializes on auxiliary Service. It responds with snap to all load fluctuations. Nozzles can be individually controlled—by hand or automatically. Groups of nozzles can be adjusted for various loads and speeds. All this means efficiency . . . economy . . . satisfaction! Three outstanding characteristics of Sturtevant engineering! Catalog 311 covers this Turbine. Our nearest branch office would be pleased to mail you a copy.

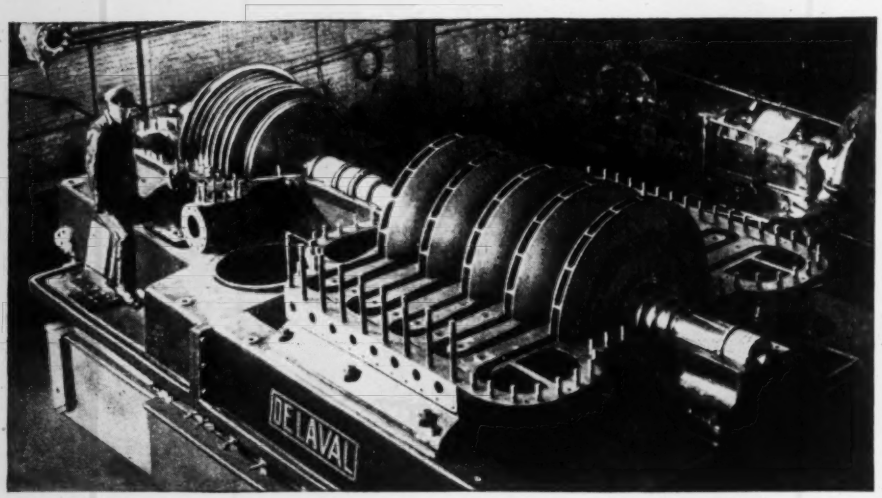
B. F. STURTEVANT COMPANY

Plants and Offices at: Berkeley, Cal. • Camden, N. J. • Framingham, Mass. • Galt, Ontario. • Hyde Park, Mass. • Sturtevant, Wis.

Branch Offices at: Atlanta; Boston; Buffalo; Camden; Charlotte; Chicago; Cincinnati; Cleveland; Dallas; Denver; Detroit; Hartford; Indianapolis; Kansas City; Los Angeles; Milwaukee; Minneapolis; Newark; New York; Omaha; Pittsburgh; Portland; Rochester; St. Louis; San Francisco; Seattle; Washington, D.C.; *Canadian Offices at:* Toronto, Montreal and Galt. *Canadian Representative:* Kipp Kelly, Ltd., Winnipeg. *Also Agents in Principal Foreign Countries.*

Sturtevant (REG. U. S. PAT. OFF.) ***Steam Turbines***

STEAM TURBINES ~ FORCED AND INDUCED DRAFT FANS ~ ELECTRIC MOTORS
FUEL ECONOMIZERS ~ GENERATING SETS ~ AIR PREHEATERS



Fully Equipped To Test

Blowers Compressors Turbines and Pumps

ALL De Laval apparatus is guaranteed as to head, capacity, steam consumption and other characteristics and is thoroughly tested before shipment. The photograph shows a five-stage turbine-driven blast furnace blower erected in the De Laval Test Room. The capacity is 60,000 cu. ft. per min. of air against 30 lbs. maximum pressure at 2800 r.p.m. Full provision is made for accurately measuring the air and also the condensate from the turbine. State your turbine, compressor, pump or speed reducing gear requirements, so that we may send appropriate literature and information.

De Laval Steam Turbine Co.

LOCAL OFFICES

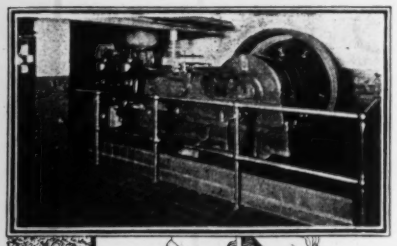
Trenton, New Jersey

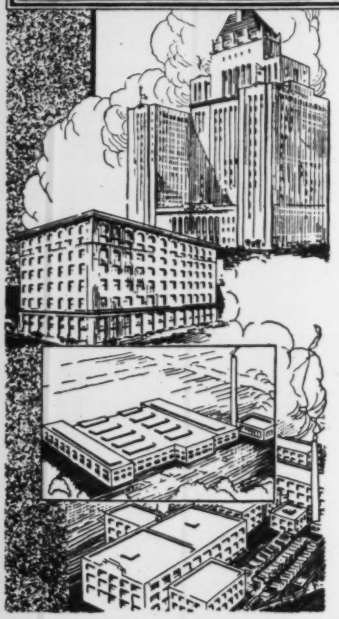
LOCAL OFFICES

Atlanta, Boston, Charlotte, Chicago, Cleveland, Duluth, Helena, Houston, Kansas City, Los Angeles, Montreal, New York, New Orleans, Philadelphia, Pittsburgh, Portland, Ore., St. Paul, Salt Lake City, San Francisco, Seattle, Spokane, Toronto, Vancouver

303

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines, Flexible Couplings and Special Centrifugal Machinery





5 SKINNER GUARANTEED SAVINGS CONTRACTS

TO SAVE $143,550 YEARLY

FIVE successive contracts to replace central station current under the Skinner Guaranteed Saving Contract were recently awarded us by two hotels, one department store, one furniture company and one manufacturing company for nine "Universal Unaflow" engines, with generators.

The total cost of the equipment we are to furnish, not erected, is $295,400.00.

The purchaser's cash payment to us, in each case, is only $1.00. In other words our entire cost of the equipment is to be paid us monthly in the savings effected against purchased electricity.

The largest contract is for $125,400.00 and the smallest for $13,500.00.

The total estimated annual saving to the purchasers is $143,550.00.

If the cost of erecting and connecting the equipment furnished is 25% of its price, then these purchasers will be making 193% per year on their investment—can they make this percentage of profit in any other department of their business?

What we can do for others we can probably do for you. Why not write us?

Write for Your Copy

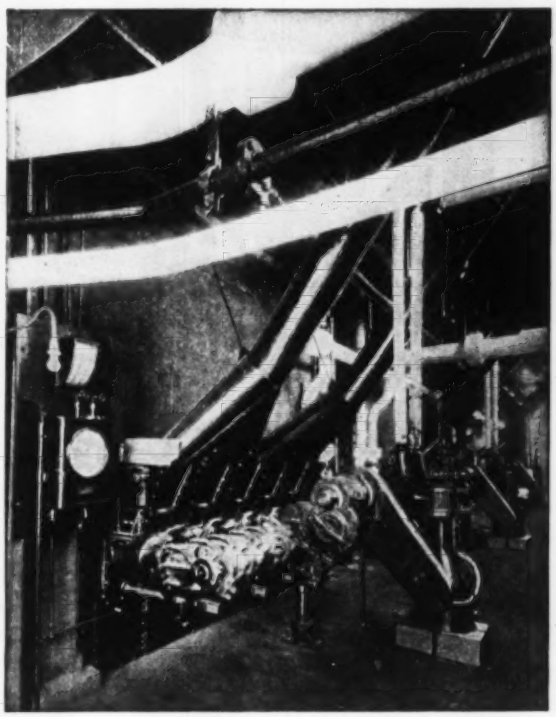
The Most Economical Steam Engine Built—

THE "UNIVERSAL UNAFLOW"

Built Only By

SKINNER ENGINE CO., ERIE, PA.

Branch Offices in all Principal Cities



On the firing line at Princeton—

The variable load carried by the modern university power plant calls for high calibre equipment. Princeton University selected

TROY
Self-Oiling
STEAM ENGINES

to drive the batteries of Taylor Stokers installed under the boilers.

The reliability of good steam engines plus the advantages of better speed control, availability of exhaust steam for heating and hot water supply usually makes them preferable to electric motor stoker drives in industrial, institutional and office building boiler plants.

Troy Self-Oiling Steam Engines because of their fully enclosed dust-tight construction, automatic pressure lubrication and self-compensating steam admission valves are especially suited to heavy duty in the boiler room.

The cylinder drains itself through the automatic lifting of the steam valve, making it entirely safe in starting.

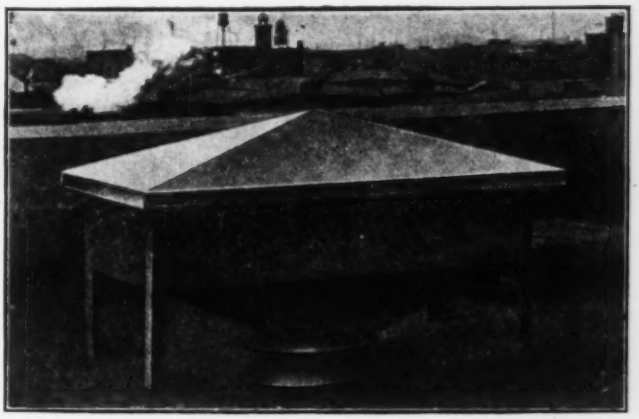
Built horizontal and vertical in rated capacities from 2 to 200 brake horsepower. Excellent deliveries—moderately priced.

WRITE FOR BULLETIN H-3

ONLY STEAM ENGINES GOOD ENGINES ONLY

Troy Engine & Machine Co.
Troy, Penna.
118 W. Ohio St., Chicago, Ill.
Distributors for Canada:
Riley Engineering & Supply Co., Ltd.
Miranda & Schell Avenues, Toronto 10, Ontario, Canada

LET OUR DATA IN



N. Y. C. R. R. Installs Protectomotor Air Filters

Illustration shows one of two 2500 C.F.M. Protectomotor Air Filters at the New York Central Power House in the new Buffalo Terminal.

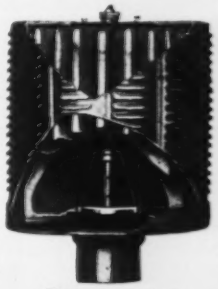
No higher tribute could be given to Protectomotor Filters than their selection for this building. For this great railroad has at its disposal some of the best engineering minds in the country—men who are exceptionally well qualified to choose the very best in any line.

Eliminate 99 9/10% of Dust

Air compressors, Diesel engines, blowers and tools will operate from 3 to 5 times longer before overhauling is necessary if equipped with Protectomotor Air Filters.

These filters are *guaranteed* to eliminate 99-9/10% of the dust and dirt from air delivered to machines. That reduces wear 75 to 85% and cuts carbon deposits 60 to 70%. Moreover, it eliminates the loss of costly compressed air which is wasted when valves are not in perfect condition; reduces oil consumption and silences noise.

Let us send you a Protectomotor on 30 days' free trial. If it does not sell itself, return it at our expense and there will be no charge. Mail the coupon, or write for our catalog.



Protectomotor

Staynew Filter Corp.
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Rochester, N. Y.

PROTECTOMOTOR
REG. U.S. PAT. OFF.
99 9/10 Per Cent EFFICIENT
AIR FILTERS

Staynew Filter Corp.
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Please send a copy of your Booklet and information about your 30 day free trial offer on a Protectomotor for use on

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Address .....

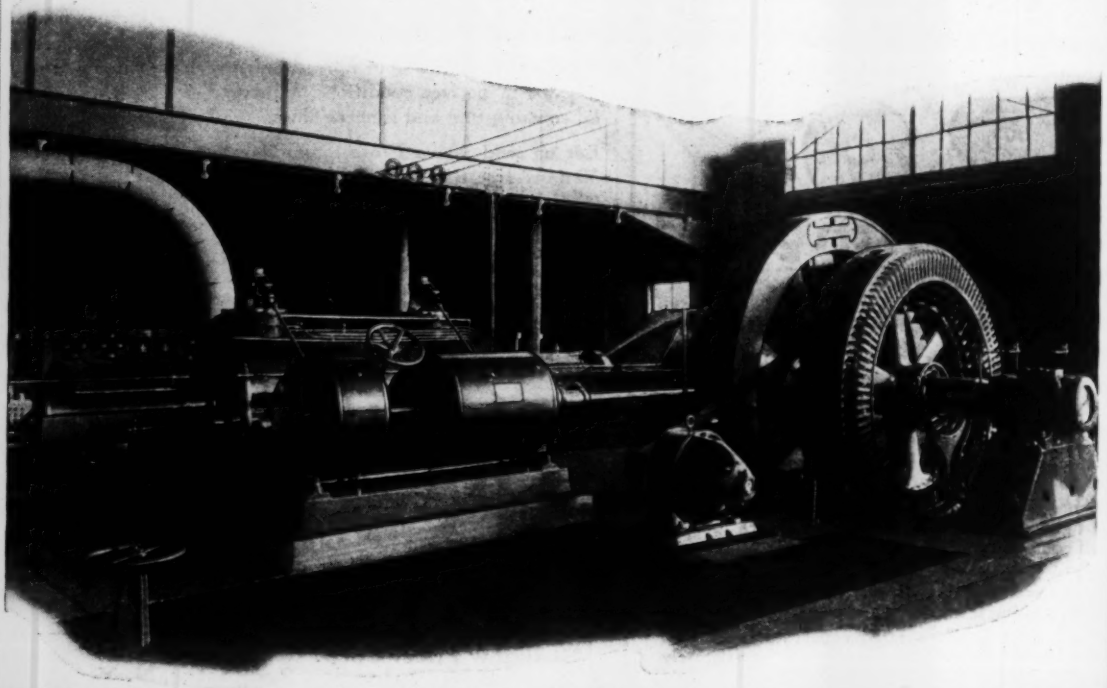
Town ..... State .....

NORDBERG
UNIFLOW ENGINE
The modern power unit

There are many small industrial power plants today operating on more efficient basis than are some of the mammoth modern generating stations. The number of kilowatts developed per pound of coal is not alone the determining factor. Where there is a demand for exhaust or process steam, the power produced is almost a costless by-product. To secure this high efficiency, however, requires the proper type of power unit, one built to meet modern steam conditions. Into Nordberg Uniflow Engines have been incorporated all those features which set them apart as being superior for the service for which they are intended.

Bulletin LG-1 describes them.

Nordberg Mfg. Co., Milwaukee



NORDBERG

Frick Refrigeration

Group Harvesting Equipment at — — Electric Ice Mfg. Co. Richmond, Va.

Frick Company
WAYNESBORO, PA., U. S. A.
ICE MACHINERY SUPERIOR SINCE 1882

For Ice-making Systems

For making the highest quality of pure ice with least horsepower, the F-P Low pressure Raw Water System offers distinct advantages over any other method. Installed in nearly 1000 ice plants in the last six years.

Frick group lift equipment enables one man per shift to harvest up to 100 tons of ice a day.

Bulletins and estimates on request.

November, 1929 MECHANICAL ENGINEERING Vol. 51, No. 11

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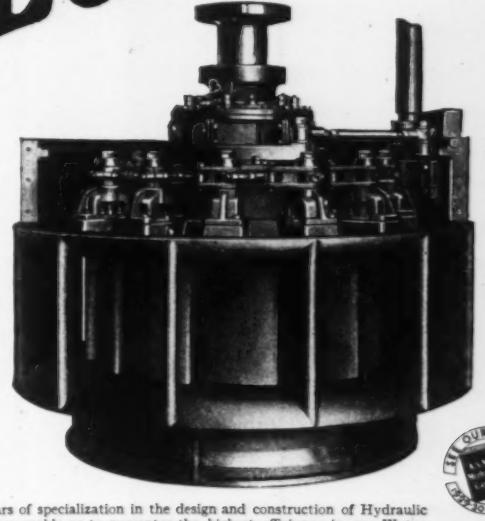
Leffel Water Wheels



67 years of specialization in the design and construction of Hydraulic Turbines enable us to guarantee the highest efficiency in any Water Power Development. To be satisfied with less, is to waste power and profits without any saving in first cost that would justify it.

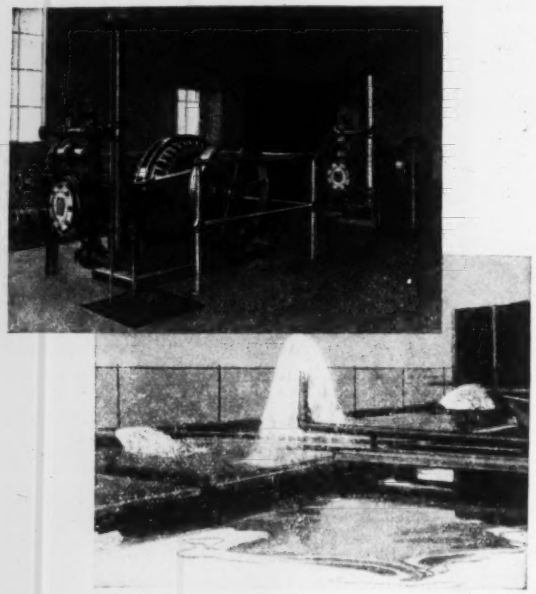
The experience of Leffel Engineers is at your service in planning a new hydro power plant or in revamping an old one, in which they may offer suggestions to your particular advantage.

WRITE FOR NEW BULLETIN W208

The James Leffel & Co. Box 504 SPRINGFIELD OHIO, U. S. A.

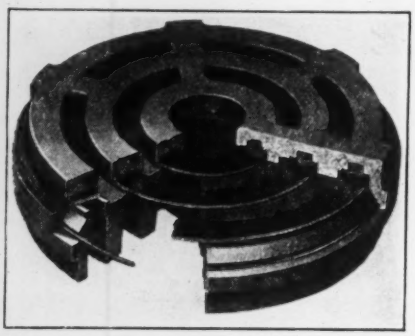
SIX BRANCH OFFICES IN CHARGE OF COMPETENT ENGINEERS

PENNSYLVANIA



The accompanying illustration shows how the Borough of Keyport, New Jersey, solved the troublesome problem of obtaining a dependable supply of pure water. Three artesian wells form the source of this supply, the water being delivered from them .....800,000 gallons daily.....by a PENNSYLVANIA Air Lift Pumping System operating in conjunction with two PENNSYLVANIA, direct connected, synchronous motor driven Air Compressors. Only one of the two compressors is in continuous service, the other unit being held in reserve as a spare. It is worthy of note that this system furnished the Borough with an abundant supply of water throughout the past season of unusually severe drought.

The compactness and clean cut appearance of the PENNSYLVANIA direct connected, synchronous motor driven air compressor is well illustrated in this installation.



PENNSYLVANIA *Air Cushioned* Valve
Neither a bolt nor nut in entire assembly.

Pennsylvania Pump and Compressor Co.
Main Office and Works, Easton, Pa.

ON EVERY HEAD

THE CHAMPION RIVET CO.

MANUFACTURERS OF
VICTOR BRAND
BOILER AND STRUCTURAL RIVETS - COUPLER AND AIR BRAKE PINS

DAVID J. CHAMPION PRESIDENT
PIERRE CHAMPION VICE PRES'T
W. J. REILLEY SEC'Y & TREAS.

MAIN OFFICE AND WORKS
CLEVELAND, O.

WESTERN PLANT
EAST CHICAGO, IND.

100% Good Riveted Work

Rivet holes should be punched or drilled, and reamed true, and then filled with perfectly round TRUE TOLERANCE Rivets—heated, avoiding scaling, to a proper heat from end to end, and driven with sufficient pressure to completely fill the holes.

Work of this kind is being done by one of the largest consumers of rivets in this country, and same applies not only to pressure work, but to structural work as well.

THE CHAMPION RIVET COMPANY

D. J. Champion
President

Dict.
DJC-M

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for student training courses and junior engineering positions.

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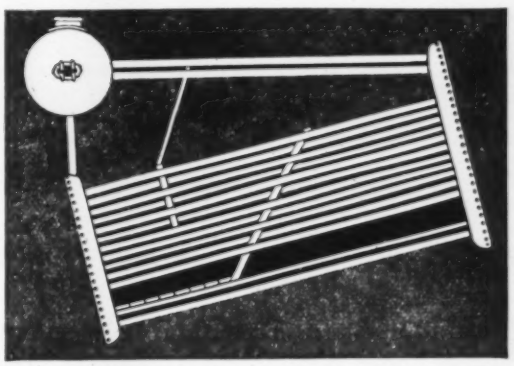
Cross Drum Boilers have been widely selected for plants having certain problems in steam generation. Their successful usage is well known, for which there are good reasons.

One of the most important is the fact that equalized and positive circulation across the full width of the headers permits high ratings and promotes heat absorption to the maximum degree.

In the success of Cross Drum Boilers, the Wickes has its part.



Wickes headers appeal strongly to engineers because each one is composed of but two plates flanged together by special machines. A metal to metal contact is secured at all points on the rivet line before the holes are drilled from the solid plate. All rivets are hydraulically driven.

Such an admittedly superior design and construction recommend themselves.

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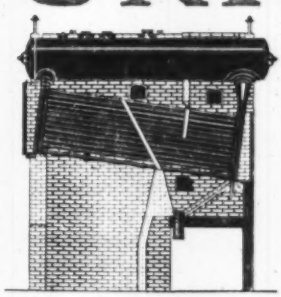
See our data in 1929-30 A.S.M.E. Mechanical Catalog

UNION WATER TUBE BOILERS



Also made in cross drum type.
(Patented.)

UNION BOILERS are built in longitudinal drum, cross drum and vertical bent tube types for practically all operating pressures and sizes.

Designed and built by an organization backed by forty years experience in the manufacture of high pressure steam boilers exclusively, in a modern and specially equipped plant.

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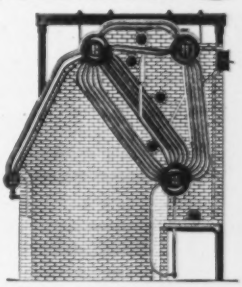

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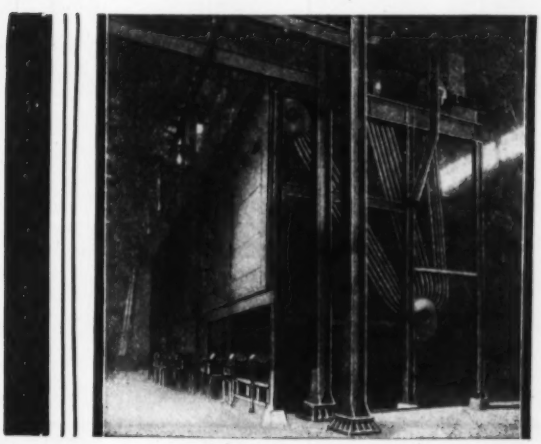

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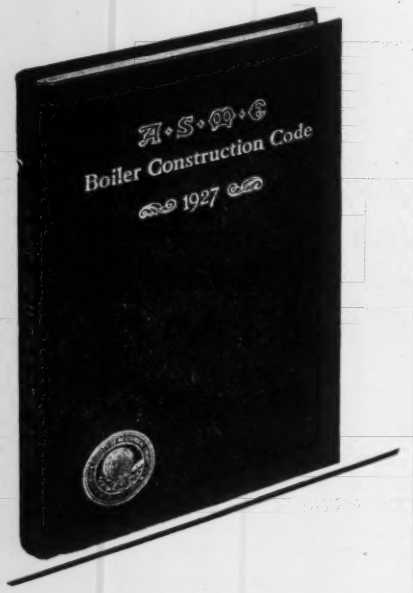

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Boiler Construction Code

EDITION OF 1927

For more than fifteen years the A.S.M.E. BOILER CONSTRUCTION CODE has been recognized as the standard guide for the design, construction, inspection, and use of power boilers. Boiler manufacturers and consulting engineers refer to it. Cities and States have adopted it as their legal construction code. Many of the leading engineering colleges throughout the country use it in their mechanical engineering course. Boiler inspectors find it an indispensable tool and one that serves constantly.

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Construction and Maximum Allowable Working Pressures for Steam Power Boilers
Ligaments
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Braced and Stayed Surfaces
Tube Sheets of Combustion Chambers
Safety Valves
Riveting
Water and Steam Gages
Setting
Stamping

Section II—Material Specifications

General Rules for Inspection & Tests, Specifications for Steel Boiler Plate, Boiler Rivet Steel, Staybolt Steel, Steel Bars, Steel Castings, Gray Iron Castings, Malleable Castings, Boiler Rivet Staybolt and Extra Refined Bar Iron, Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, Welded and Seamless Steel Pipe, Wrought Iron Pipe, Copper Plates, Copper Bars for Staybolts, Seamless Copper Boiler Tubes, Brass Pipes, Carbon Steel Castings for Valves, Flanges and Fittings for High-Temperature Service, Carbon-Steel and Alloy-Steel Forgings, and Seamless Steel Drum Forgings.

Appendix

Embracing explanatory notes and recommendations relating to boiler construction.

Index

Completely and carefully arranged.

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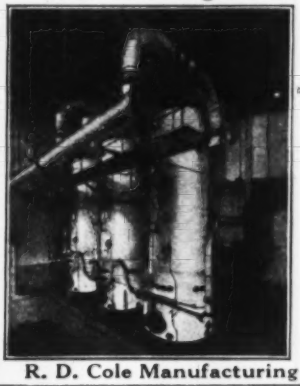

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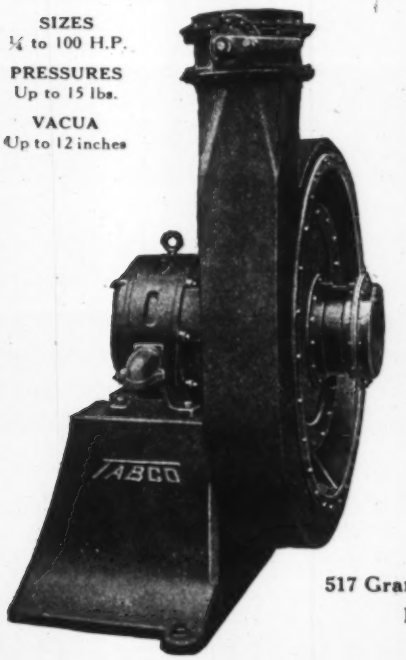

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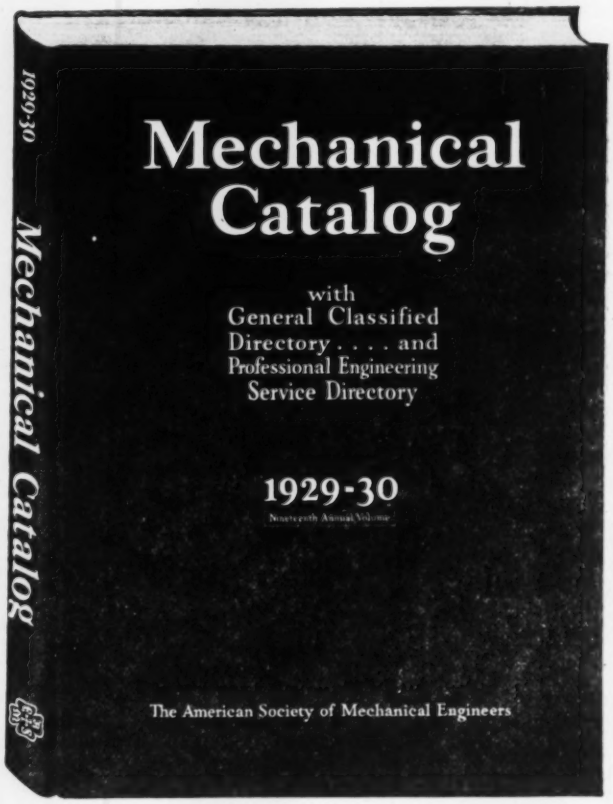

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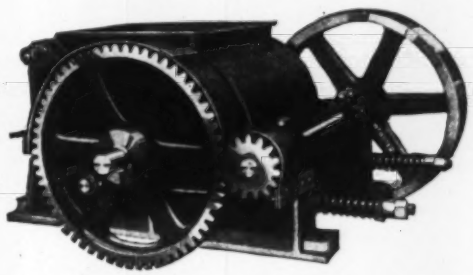

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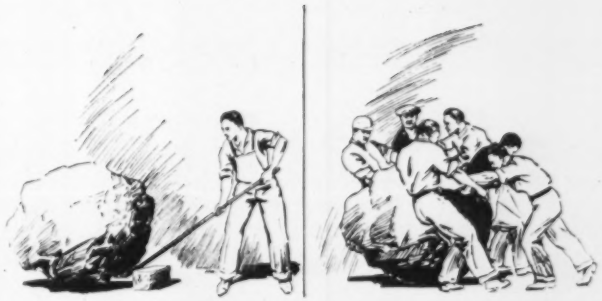

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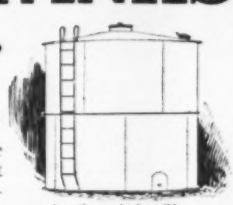

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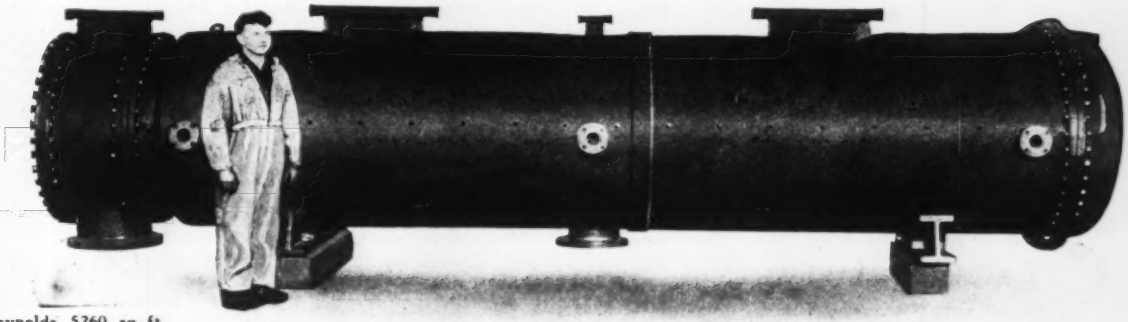

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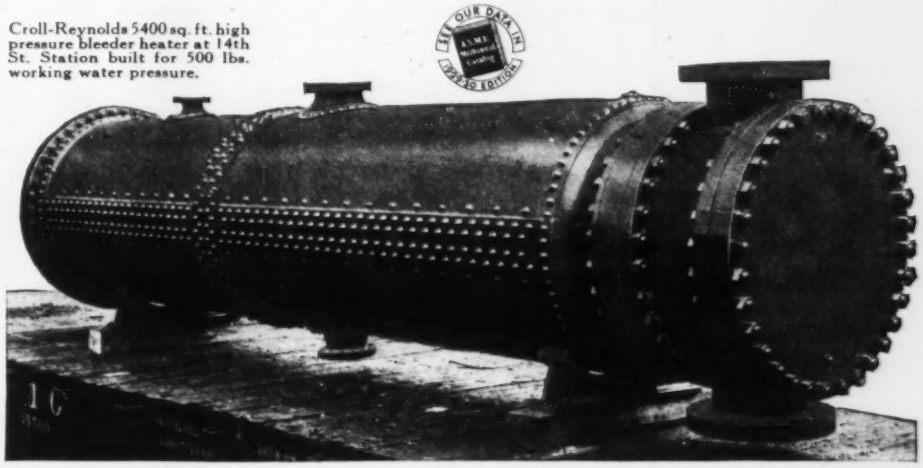

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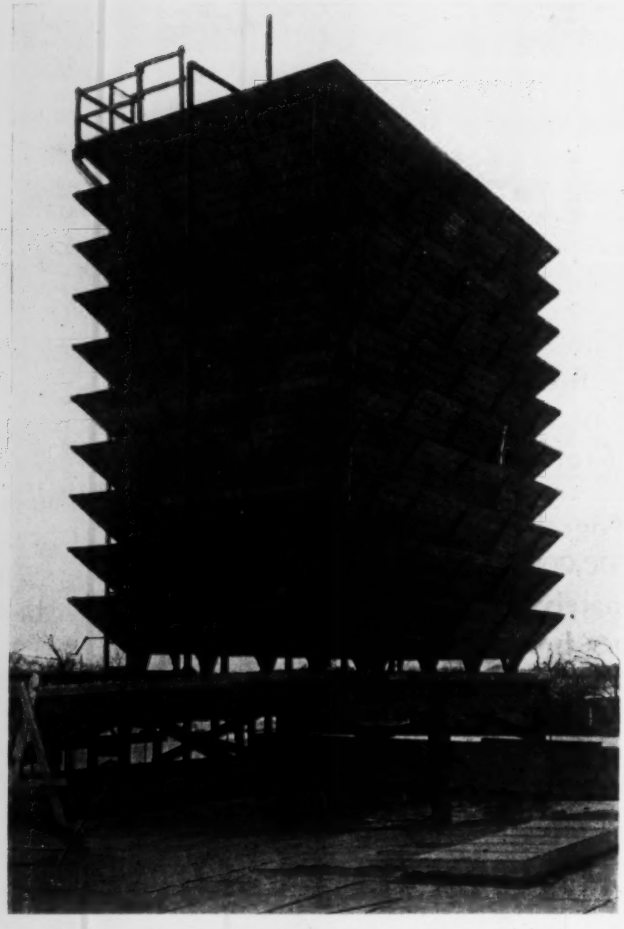

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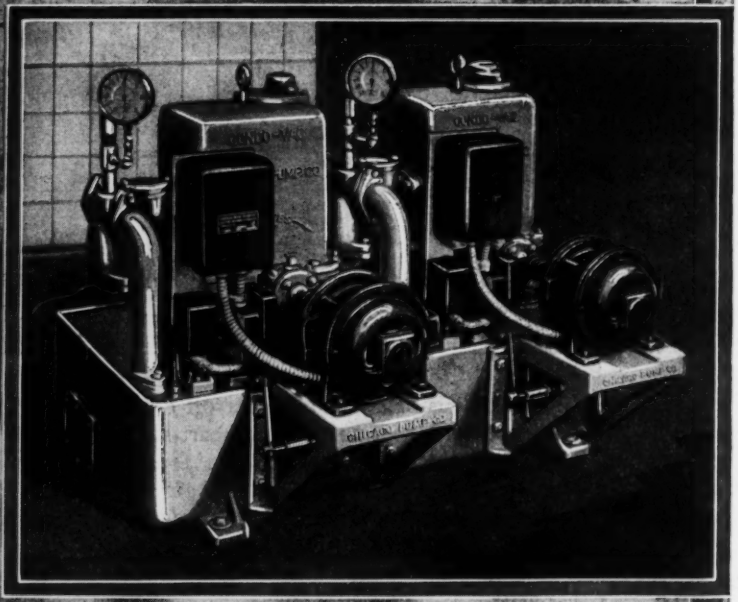

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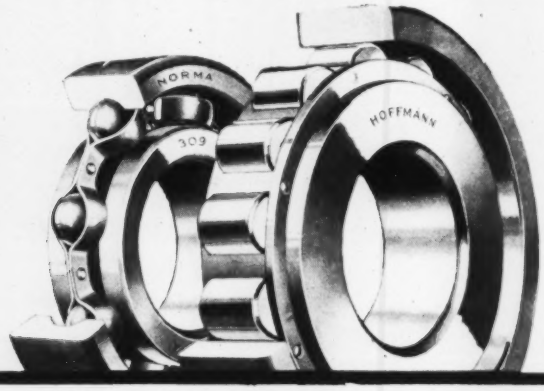
EIGHTH

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

At the ~ Grand Central Palace ~ New York, N.Y.

December 2nd to 7th, 1929

BOOTH 312—NEW YORK POWER SHOW—DEC. 2 to 7



PRECISION

. . . its meaning and its commercial value . . .

PRECISION, as commonly used, is a term defining extreme refinement of dimension and finish. But as describing an outstanding quality of *NORMA-HOFFMANN Precision Bearings*, the word has a far more comprehensive meaning.

To Norma-Hoffmann engineers and production men, *Precision* means the ultimate in dimensional refinement. Above and beyond this, however, it means bearing design worthy of expression in a finished product of this extreme refinement—selected materials well deserving of special treatments and of highly refined machining processes—standards of production which permit no deviation from absolute uniformity, regardless of quantity.

Precision, as thus described, is the foundation quality upon which the Norma-Hoffmann reputation rests, upon which its business has been built, and upon which it must continue to grow.

But what does all this mean to the buyer and user of *NORMA-HOFFMANN Precision Ball and Roller Bearings?* What, in other words, is the commercial value of *Precision?*

Briefly stated, *Precision* stands for that combination of qualities which manifests itself in higher anti-friction efficiency, longer life, greater speedability, better performance, lower costs for replacements, increased production. These are the distinct and concrete advantages which accrue to the user of *NORMA-HOFFMANN Precision Bearings.*

Obviously, *Precision* is costly to produce and to maintain. But it has been the uniform experience of those who have availed themselves of its advantages, that its price is repaid a hundred fold in the lower after-costs which inevitably follow.

The long, varied experience of Norma-Hoffmann engineers is offered without obligation to machine users and builders facing bearing problems.

"NORMA-HOFFMANN"

PRECISION BEARINGS

NORMA-HOFFMANN BEARINGS CORPN.-STAMFORD CONN. U.S.A.

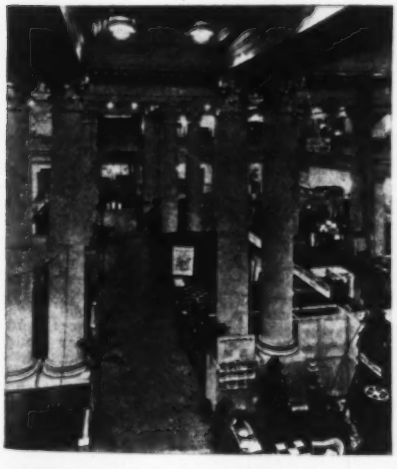
Eighth National Exposition of Power and Mechanical Engineering

THE "A.S.M.E. Guide" to the New York Power Show although issued as an aid to A.S.M.E. members while attending the Show in person is also extremely valuable to those who are prevented by business or personal responsibilities from being in New York City during the week of the A.S.M.E. Annual Meeting and the Power Show.

Even for those who are able to spend an afternoon or an evening at the show, it is quite a task to make a complete inspection of the approximately 450 booths which invite attention; and in many of which, alone, the average visitor could spend a large part of his available time to advantage.

Preliminary study of the "Guide" before visiting the Power Show helps to overcome this difficulty by enabling a prospective visitor to select in advance those exhibits which seem most likely to be of definite value to him; and to give them first attention during his visit. In many instances also, the Guide will prove valuable after a visitor has left the Show as a means of checking up names, addresses, or details regarding the equipment examined.

The value of an adequate printed record of the concerns exhibiting at

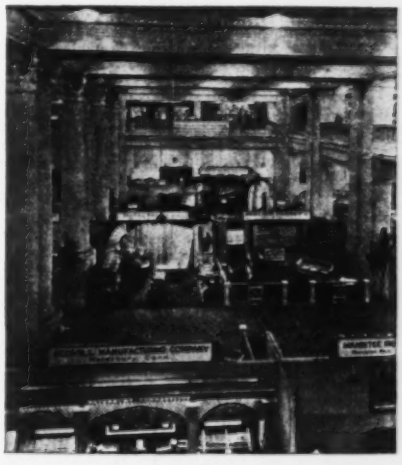


the New York Power Show, and of the nature of their respective exhibits, has thus become so thoroughly evident that MECHANICAL ENGINEERING presents again a complete "Directory of Exhibitors" giving a brief description of each exhibit so far as it has been possible to secure the information in advance of the Show. This data, which begins on page 74 and extends over alternate pages to page 94, has been compiled very carefully, and submitted to the Management of the Exposition for checking; but we cannot guarantee its accuracy in detail because of inevitable changes between the date of going to press and the opening of the Show. The names of concerns presenting advertisements in the "Guide" appear in color with a reference to the page or pages, upon which their advertisement appears.

In each write-up the number, or numbers, of the booths occupied are given, so that turning to the floor-space diagrams shown on pages 106, 108 and 110, a user of the Guide at the Show can readily locate any booth in which he is interested. A.S.M.E. members are especially invited to visit the A.S.M.E. Booth (No. 80) on the main floor near the front entrance, where members of the Staff will be in attendance throughout the Show, and full information regarding A.S.M.E. activities and publications will be available.

Present indications point to an unusually interesting Show this year. The exhibits promise to be more varied. A preliminary analysis of the exhibits of the 420 exhibitors shows that a large majority of the exhibits will contain machinery or equipment for the generation, distribution or utilization of power; other exhibits will relate to heating, ventilating or refrigeration; a number of exhibits will show instruments for indication or control of pressure, temperature, volume, time, or speed; others will show Safety Appliances; there are exhibits of Professional Engineering Service; and a representative group will show some form of machine shop or metal-working equipment. In addition there will be exhibits covering classifications such as material handling, engineering materials, etc.

Aside from its commercial aspect the Exposition offers other opportunities which although less obvious, are almost as important in their contribution toward the upbuilding of the engineering industries. The A.S.M.E. members whose connection with mechanical engineering matters has become highly specialized will find it an enjoyable means of "brushing up" their general knowledge; and securing a personal contact with more



recent developments, regarding which they might otherwise be too much dependent on their engineering associates or assistants. The younger members, on the other hand, and particularly those who are just entering the engineering field may readily secure a fund of practical and commercial information which will constitute an important supplement to their recent technical education.

As in previous years the New York Power Show is being held during the same week as the A.S.M.E. Annual Meeting; and a special invitation is extended to all A.S.M.E. members to attend. Tickets of admission can be had without charge at Society headquarters; and an A.S.M.E. emblem seldom fails to secure for its wearer even more than the usual degree of courteous attention accorded to visitors at booths. In many cases the managers of the booths are A.S.M.E. members themselves; and are glad, accordingly, to welcome a visitor with whom they have a common interest.

See Pages 74-94 for Directory of Exhibitors

See Pages 106-110 for Floor Diagrams

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* **Booths No. 200 to 348—Second Floor—*Diagram on Page 108***
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Corrected to November 19th — **Booth**

Advance Engrg. Co. 272–274
168 Washington St., New York, N. Y.
Representing: A. W. Cash Co., Kelly Co., Smith-Monroe Co.

Aerofin Corp'n 14A
750 Frelinghuysen Ave., Newark, N. J.
Will display a complete line of Aerofin Heaters, covering Low Pressure, Universal and High Pressure Aerofin; also Booster Coils.

Alexander Bros. 269, 270
14 South St., Philadelphia, Pa.
Exhibiting their Tentacular Transmission Belt on several typical short center drives having high pulley ratios.

Allegheny Steel Co. 433
Brackenridge, Pa.

Allen Air Appliances Co. (Inc.) 241–243
452 Lexington Ave., New York, N. Y.
Will exhibit a complete line of "Triple-A2" Centrifugal or Turbo Blowers and Exhausters together with Heavy Duty Industrial Pneumatic Sweeping Systems of the Portable and Stationary type. Actual demonstrations of Heavy Duty Vacuum Cleaners will be made.

Allen-Bradley Co. 558–560
490 Clinton St., Milwaukee, Wis.
Will exhibit a complete line of A. C. and D. C. Hand and Automatic Motor Control Equipment, Battery-charging Switchboards, and a line of new devices such as overload protectors for small motors, starters with incorporated disconnect switches, and oil burner control panels.

Allen Mfg. Co. ..... Mezzanine "A"
133 Sheldon St., Hartford, Conn.
Will exhibit commercial forms of monel metal and pure nickel as used for manufacture of vital parts of power plant equipment; also specimens of such parts donated by manufacturers to demonstrate properties of the metals for which they are selected.

Allen-Sherman-Hoff Co. 62, 63
233 S. 15th St., Philadelphia, Pa.
Will have a Scene-In-Action display showing the complete operation of the Hydrojet System of Ash Removal. Will also have on display a Cutaway Ash Pump. The way this Pump will be cut will clearly show the various operating parts. This pump is a new development in the past year. Will also have on display an Allen-Sherman-Hoff Soot Valve.

Allen & Billmyre Co. 457, 458
517 Grand Central Palace, New York, N. Y.
Exhibiting a complete line of TABCO Centrifugal Multi-Stage Blowers and Exhausters, Heavy Duty Portable and Industrial Vacuum Cleaners and also TABCO Stationary Vacuum Cleaners as applied to power plant work. This unit shows a new type of material collecting tank and discharger.

Allis-Chalmers Mfg. Co. 515–517
Publicity Dept., Milwaukee, Wisc.
Manufacturers of Power, Electrical and Industrial Machinery, Hydraulic Turbines, for all sizes and heads, Pumping Engines, Centrifugal and Plunger Pumping Units, and Texrope Drives.

Allpax Co. (Inc.) 608
Mamaroneck, N. Y.
Exhibiting Allpax, the packing that "packs all," in Coil Form and Loose Form.

American Arch Co. (Inc.) 58
17 East 42nd St., New York, N. Y.
Exhibit will include full size models of the American Suspended Arch and Arch Lock Brick and Tile, also Air Cooled Side Walls.

American Blower Co. 314, 315, 321, 322
6000 Russell St., Detroit, Mich.
Manufacturers of all kinds of Heating, Ventilating and Air Conditioning Equipment, will have on exhibition a complete line of Unit Heaters. The display will consist of Universal, the improved Sirocco, and the new Venturafin Unit Heaters.

American Brass Co. 65
Waterbury, Conn.
Will exhibit Admiralty and Ambrac Condenser Tubes, Condenser Head Plates, Everdur Metal, Anaconda Welding Rods, Anaconda Brass Pipe, Copper Tubes for use with Compression Fittings, Extruded Shapes, Die-Pressed Parts, Rods, Bars, and Segments, and Anaconda Sheet Metal.

American Car & Foundry Co. 201
30 Church St., New York, N. Y.
Will exhibit a No. 3 three-electrode a.c.f. Berwick Electric Rivet Heater, for heating rivets; and a No. 3 one-electrode a.c.f. Berwick Electric Metal Heater, for heating, for forging or upsetting.

American Gas Assoc'n (Inc.) 7
Graybar Bldg., New York, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

American Locomotive Co. 417
30 Church St., New York, N. Y.

American Mason Safety Tread Co. 432
Lowell, Mass.
Exhibit will include Mason Carbo-Cast and Mason Structural Non-Slip Stair Treads and Landings, Trench Covers, Floor Plates, Stanwood Grating and Steps, Ladder Shoes, Abrasive Flooring, and other Mason Safety Tread Products.

American Metal Hose Co. 291
Waterbury, Conn.
Will show a complete line of Flexible Metal Hose and Tubing, made from Aluminum, Brass, Bronze, Galvanized Steel, Monel, Rustless Iron and other workable alloys.

American Pipe Bending Mch. Co. (Inc.) 640
37 Pearl St., Boston, Mass.
Exhibiting new type 2" Power Operated Cold Pipe Bender for bending double thick pipe, and a new type tubing bender to bend thin gauge steel, brass and copper tubing up to 1¼" O. D. to radius of about 2–1 or twice the diameter.

American Radiator Co. 544
40 West 40th St., New York, N. Y.
An interesting exhibit of MERCOID electric instruments for direct across the line control of temperature, pressure, vacuum, liquid level, etc. Also Arco Motor Valves, Arco Solenoid Valves and other industrial automatic controlling devices.

American Schaeffer-Budenberg Corp'n 60
338 Berry St., Brooklyn, N. Y.

American Society of Heating and Ventilating Engineers .....
29 West 39th St., New York, N. Y.
Facilities will be provided for welcoming Society members and furnishing all information concerning Society activities.

American Society of Mechanical Engineers 80
29 West 39th St., New York, N. Y.
A.S.M.E. Headquarters at the Power Show. Information may be had about Annual Meeting and other A.S.M.E. activities. Publications of the Society will be on exhibition.

American Water Softener Co. 72
Lehigh Ave. and 4th St., Philadelphia, Pa.
Will exhibit wash drawings of continuous water softener types. Also, photographs of installations of various kinds and literature covering water softeners and filters.

Ames Pump Co. (Inc.) 417, 418
30 Church St., New York, N. Y.
Will exhibit Pumping Apparatus for use in connection with vacuum heating systems with particular reference to the vacuum pump with detailed parts shown in sections in order to describe and illustrate the unit.

Anaconda Copper Mining Co. 65
25 Broadway, New York, N. Y.

Andale Company 92, 93
1600 Arch St., Philadelphia, Pa.
Exhibiting Strainers for Oil and Water, Types Simplex, Duplex and Rotrex; Oil Coolers; and Heat Exchangers.

Appleton Electric Co. 507
1739 Wellington Ave., Chicago, Ill.
A very interesting exhibit of their products, the most important of which are Threaded and No-Thread Malleable Unilets and miscellaneous conduit fittings. Included also in the exhibit are Reelites both in Portable and Constant Duty types.

Armstrong Cork & Insulation Co. 342, 343
911 Concord St., Lancaster, Pa.
Exhibit will include their various heat insulating materials such as Armstrong's and Nonpareil Insulating Brick, Armstrong's Corkboard Insulation and Armstrong's Cork Covering Nonpareil High Pressure Covering and Blocks.

Armstrong Machine Works 271
316 Maple Street, Three Rivers, Mich.
Will exhibit a glass model of the Armstrong Steam Trap operating under steam pressure whereby the operation under actual conditions and the many advantages incorporated in their design may be observed. Will also show complete line of traps.

Ashton Valve Co. 38
161-179 First St., Cambridge 41, Boston, Mass.
Exhibiting Ashton Pop Safety and Relief Valves; Pressure and Vacuum Gages; Dead-Weight Gage Testers of the double area type; Master Pilot Pressure Gages, single or double illuminated dial; Inspector's Screw Test Pump, etc.

Ass'n of German Shearing and Punching Machine Manufacturers 244
Hagen, Germany

Atlas Oil Burner Corp'n 415
Brooklyn, N. Y.
Showing Oil Burners.

Atwood & Morrill Co. 552, 553
Salem, Mass.
Exhibit will consist of Turbine and Condenser Equipment, showing for the first time a special Bleeder Valve which has been designed in conjunction with one of the leading turbine manufacturers, for use in connection with turbine bleeder service.

Austin Heat Transference Corp'n 227, 228
Port Chester, N. Y.
New rapid heat transfer boilers.

Automatic Switch Co. 551
154 Grand St., New York, N. Y.
Exhibit consists of a complete line of "Asco Valve." These valves are of the Solenoid Magnet Operated type in sizes from ¼" to 12" and for various gases and fluids. In addition will exhibit heavy duty and Automatic Transfer Switches.

Babcock Wilcox Tube Co. 229
Beaver Falls, Pa.
Specimens of seamless steel tubes, Enduro and Toncan iron tubes and pipe, will be shown.

Babcock & Wilcox Co. 55
85 Liberty St., New York, N. Y.
The exhibit will include sections of forged steel drum nozzles of various designs, together with specimens of Babcock & Wilcox welding practice. Sections of latest designs in steam superheaters and fuel economizers will be shown. An exhibit of unusual interest is a sectional model of a Babcock & Wilcox cross-drum boiler complete with superheater, air heater, economizer and Bailey furnace walls, equipped with a Westinghouse stoker. There will also be a display of Babcock & Wilcox refractory products, such as standard and special firebrick shapes, cements and plastics.

Badger, E. B., & Sons Co. 565, 566
63-75 Pitts St., Boston, Mass.
See Adv. Page 104
Exhibit will consist of various types of Expansion Joints such as the Badger Self-Equalizing Expansion Joints, both flanged and welding types, and the Badger Single and Multiple Corrugation Low Pressure Expansion Joints.

Bailey Meter Co 51
1026 Ivanhoe Road, Cleveland, Ohio
See Adv. Pages 116, 117
Exhibit will show the following products: Bailey Meter Automatic Control as applied to the operation of steam boilers and to the maintenance of various factors in process work; Bailey Thermo Hydraulic Feed Water Regulators, Pump Governors, and Excess Pressure Regulators; Bailey Fluid Meters of both the mechanically and electrically operated types for the measurement of steam, water, gas and other fluids; and Selsyn operated devices for long distance transmission of readings of pressure temperature, draft, liquid level, motion, speed and other factors.

Baker, R. H., Co. (Inc.) 323, 324
Kendall Square Bldg., Cambridge, Mass.
Will exhibit photographs of recently completed installations and will have actual test specimens of welding used in pipe line construction, together with data on these tests.

Baker Supply Company 323, 324
145 Broadway, Cambridge, Mass.
Will exhibit samples of merchandise that they

Continued on page 76

"MAKE ASSURANCE DOUBLE SURE"

BERNITZ SUPER BLOCKS

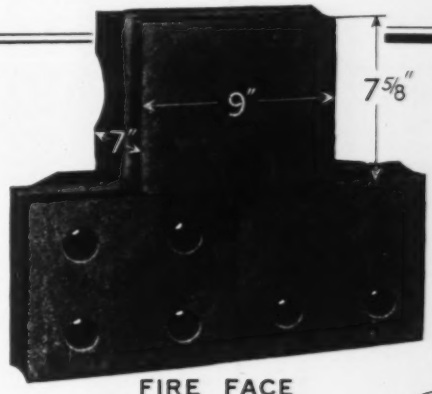
WHEN you purchase Bernitz "Carbofrax" ventilated Linings for your boiler settings The Carborundum Company as well as the Bernitz Furnace Appliance Company stand back of the quality of the material supplied.

"Carbofrax" has been selected for Bernitz Super Blocks because it is a true silicon carbide refractory containing no foreign bond. This material has greater mechanical strength, freedom from spalling and in itself is highly resistant to slag and flame erosion, clinker adhesion and high temperatures.

But the severity of service encountered in modern furnaces, particularly in the portion of the settings adjacent to the fuel zone, is a toll upon even the highest grade refractories. It therefore becomes highly desirable to increase the life of such materials and the Bernitz Construction has proven itself the best way of doing this, adding greatly to the life and but little additional to the initial cost.

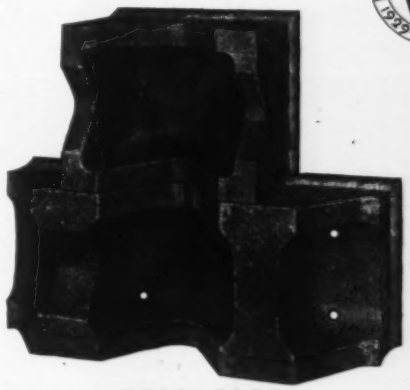
"Carbofrax" is the ideal material to use. It has the highest thermal conductivity of any commercial refractory (9 to 11 times fire clay) which together with its greater mechanical strength and the Bernitz ventilated Constructions provides the protection economically needed in modern boiler furnaces. Frequent boiler outages and setting repairs are eliminated.

Bernitz "S-100" type "Carbofrax" blocks shown here are particularly adapted to Stoker fired furnaces. Other types are manufactured for every furnace need including Bernitz Co. Nygaard "Carbofrax" Blocks for water walls.



FIRE FACE

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1929-30 EDITION



REAR FACE

Competent engineers are present at

BOOTH NO. 78
NEW YORK POWER SHOW
Dec. 2 to 7, 1929

to discuss your furnace wall problems.

BERNITZ FURNACE APPLIANCE COMPANY

Water Wall Construction, "Carbofrax," Fire Clay, and Cast Iron Facing Blocks for new or existing water wall installations.

Main Office:
89 Broad Street
Boston, Mass.

District Offices in Principal Cities

Bernitz "Carbofrax" and Fire Clay, Air-Cooled Boiler Furnace Walls and Floors. Perforated and Non-Air Admission Types.

Bernitz "Carbofrax" Blocks are made for us exclusively by The Carborundum Company

"Carbofrax" is the Registered Trade Mark of The Carborundum Company for refractories of its manufacture.

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

handle which consist of Pipe, Valves, Fittings and Mechanical Equipment, Steam Specialties, etc.

Baldwin Chain & Mfg. Co. 509
Southbridge St., Worcester, Mass.
Exhibit will consist of chains and sprockets for power transmission and conveying of materials—a Display Board and also a moving power exhibit.

Ballwood Company 221, 222
30 Church St., New York, N. Y.
(See Midwest Piping & Supply Co.)

Barco Manufacturing Co. 247
1801 Winnemac Ave., Chicago, Ill.
See Adv. Page 102
Will exhibit at the Power Show this year Barco Lubricated Plug Valves type LCI and MCI, also Barco Flexible Joints, and Barco Swivel Joints, together with electrically operated-models, cut-open sections, etc.

Barnes, W. O., & Co. 511
Detroit, Mich.
Manufacturers of Saws

Bauer & Black 522, 523
2500 S. Dearborn St., Chicago, Ill.
Will exhibit Surgical and First Aid Supplies for use by Industrials, Public Utilities, etc. Uniflex First Aid Kits, Non-ravel Bandages, Zinc Oxide Adhesive Plaster on spools, and Rack Spool Adhesive for First Aid Rooms.

Bausch & Lomb Optical Co. 602
635 St. Paul St., Rochester, N. Y.
Exhibit will include Microscopes and Accessories, Microtomes and Optical Measuring Instruments, including their new Hydrogen-ion Colorimeter for pH Determinations, Quartz Monochromator, Spectrophotometric equipment, Micro Projection Apparatus Magnifiers and Readers, Toolmaker's Microscope and other instruments.

Bearium Bearings (Inc.) 288
261 Franklin St., Boston, Mass.
Exhibiting Bearium Metal Bushings.

Belfield, H., Co. 550
435 N. Broad St., Philadelphia, Pa.
Exhibiting controllers, stop, Regulators steel, brass and Iron VALVES. Direct or remote controlled. Brass and Iron COCKS; and Brass Screwed and Flanged FITTINGS.

Bernitz Furnace Appliance Co 78
89 Broad St., Boston, Mass
See Adv. Page 75
Will exhibit in particular the Bernitz S-100 type of "Carbofrax" ventilated Blocks for boiler furnaces. Exhibit will be arranged so as to show the methods of ventilation used in the Bernitz air-cooled construction and the layout will also be shown showing how this type of construction is adapted to air admission over the retorts in the front wall of stoker fired furnaces. Will further exhibit a portion of the Bernitz Co. Nygaard type of "Carbofrax" block used for covering water walls. This was a new construction first shown last year and there are several improvements that will be shown this year.

Bethlehem Steel Co 70, 71
Bethlehem, Pa.
See Adv. Page 77
Will exhibit the following products: Bethlehem Pulverizer, Bethlehem-Dahl Oil Burning System, Bethlehem Torque Amplifier, Bethlehem Pipe, and Engine Bolt and Stay Bolt Iron and Steel.

Biax Flexible Shaft Co. 508
20 East 17th St., New York, N. Y.
The products shown will be: Flexible shafts, and Flexible Shaft Machinery, also rotary files for die work. Also showing Multi Biax Units Type FSA to FSD. Will also show various grinders and flexible shaft machines for buffing, polishing, grinding, sanding and are featuring a new 1/2 Horse Power three-speed equipment with right angle gear for disc sanding.

Bigbie Grate & Forced Draft Equip. Corp'n ... 316
90 West St., New York, N. Y.
Exhibiting Grates for all purposes and blowers which are for ventilating and forced draft systems.

Biglow, L. C., & Co. (Inc.) 263
250 West 54th St., New York, N. Y.
Representing: Davis Boring Tool Co., Hanson Whitney Machine Co., Scully-Jones Co.

Booth

Binks Mfg. Co. 632, 633
3114 Carroll Ave., Chicago, Ill.
Will exhibit Spray Pond Equipment, Nozzles and other accessories as used for the construction of complete cooling ponds, also a line of Paint Spraying Machinery as adapted for maintenance work.

Bishop Wire & Cable Co. 643
420 E. 25th St., New York, N. Y.
Exhibit will consist mainly of the new Bishop Contact Cable.

Black & Decker Mfg. Co. 290
Towson, Md.
Exhibiting Portable Electric Tools.

Boig & Hill (Inc.) 250
180 Washington St., New York, N. Y.
Representing: Julian d'Este Company.

Boiler Engineering Co. 450
931 Federal Trust Bldg., Newark, N. J.
The exhibit will make clear the difference between unyielding monolithic boiler baffles and the yielding flexible BECO Boiler Baffle. BECO Tube Blocks, which are used in baffle wall construction by the Boiler Engineering Co., will be exhibited. Photographs of numerous installations will also be on display.

Bond, Chas., Co. 485
617 Arch St., Philadelphia, Pa.
Showing a large variety of Bond Standard Stock Gears as well as displaying two rather interesting moving exhibits showing the application of the various types of gears. Will also show a complete line of the Special Tanned Flat Leather Belting, Oak Tanned Flat Belting, as well as BONDARON Special Tanned Round Leather Belting.

Bond Foundry & Mach. Co. 486
Manheim, Pa.
Will exhibit Truck Casters and Power Transmitting Machinery, also Commercial Roller Bearings. Will show a number of improved designs of Truck Casters.

Borden Co. 248, 249
350 Dana Ave., Warren, Ohio
Will display their full line of Easy-Cutting Die Stock, Square-End Pipe Cutters and Power Drives.

Boston Gear Works Sales Co 326-331
Norfolk Downs, Quincy, Mass.
See Adv. Page 124
Will exhibit a full line of their standardized Speed Reducers, including a series of Speed Reducers for light duty, equipped with Timken Tapered Roller Bearings. Will also exhibit Adjustable Shaft Supports equipped with Fafnir Ball Bearings, as well as Ground Tooth Gears.

Botfield Refractories Co. 94
Swanson & Clymer Sts., Philadelphia, Pa.
Will exhibit Refractory Materials, including ADAMANT Fire Brick Cement; ADACHROME Fines and Aggregate; ADAPATCH, and the ADAMANT Gun.

Bowser, S. F., & Company 620, 621
Fort Wayne, Ind.
Exhibit will consist of their standard line of lubricators, filters and other specialties of a like nature.

Breuer Electric Mfg. Co. 462
844 Blackhawk St., Chicago, Ill.
Showing Two Models of Tornado Portable Electric Blowers, New Tornado Portable Electric Paint Sprayer; and Tornado Industrial Vacuum Cleaner. All of these machines will be demonstrated, displaying the working parts and construction.

Bristol Company 12
Waterbury, Conn.
See Adv. Page 122
Will have on demonstration a complete line of Indicating and Recording Instruments including Pressure and Vacuum Gauges, Thermometers, Voltmeters, Ammeters, Wattmeters, Shunt Ammeters, Differential Recorders, Control Valves, etc. Features of special interest will include Electrical Instruments of improved design and models. Also Air Operated Draft Controller.

Brooklyn Boro Gas Co. 7
Coney Island, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

Booth

Brooklyn Union Gas Co. 7
176 Remsen St., Brooklyn, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

Brown Instrument Co. 49
4486 Wayne Ave., Philadelphia, Pa.
A prominent feature of the exhibit will be a line of Distant Dial (Remote Type) Gauges for use where instruments are required to record or indicate pressures and liquid levels from points which may be located at distances of as much as 30 miles. The display will be in the form of an instrument board; a supplementary display will be arranged on tables exhibiting the following: Brown CO_2 Cell Brown Portable, Indicating Pyrometer; Brown Portable Potentiometer; Brown Pressure Manometer (used with Brown Flow Meter on high pressure service); Brown Resistance Thermometer Bulb; Brown Sampling Tube for CO_2 Meter; Brown Motion Transmitter; and Brown Valve Mechanism for Automatic Control.

Bryan Boiler Co. 537, 538
Greenwich, Conn.
Will have No. 10 Bryan Gas Fired Copper Tube Boiler on display with the Gas burner equipment complete, also one No. 8 Bryan Oil Burning Copper Tube Boiler.

Builders Iron Foundry 28
19 Codding St., Providence, R. I.
Showing an attractive exhibit including their usual line of Meters, which will include the Venturi Meter, Type GK Diaphragm Orifice Meter and the small Shunt Meter for Steam, Air or Gas.

Bundy Steam Trap Co. 8
39 Elm St., Nashua, N. H.
Showing a complete line of Bundy Traps and their application.

Burhorn, Edwin, Co. ..... "A" Main Fl
West 5th St., Bayonne, N. J.
Featuring their new distributing system for Cooling Towers and will show a model in operation. The distribution is unique in that the water is distributed evenly over the entire area of the tower through gravity action. A large number of illustrations will be shown.

Byers, A. M., Co. 232, 233
235 Water St., Pittsburgh, Pa.
Showing display material illustrating length of service of Wrought Iron Pipe taken from various installations all over the country.

Campbell, Andrew C. (Inc.) 481, 482
Bridgeport, Conn.
Exhibit will show the uses and users of Campbell Nibbling Machines and will have four machines in actual operation cutting parts from steel.

Carboloy Co. (Inc.) 336-339
350 Madison Ave., New York, N. Y.
Will exhibit Carboloy Cemented Tungsten Carbide Tools, Gauges, Dies and specimens of material machined by Carboloy. A 30-H. P. turret lathe will be used for demonstration runs on cast iron, steel, etc.

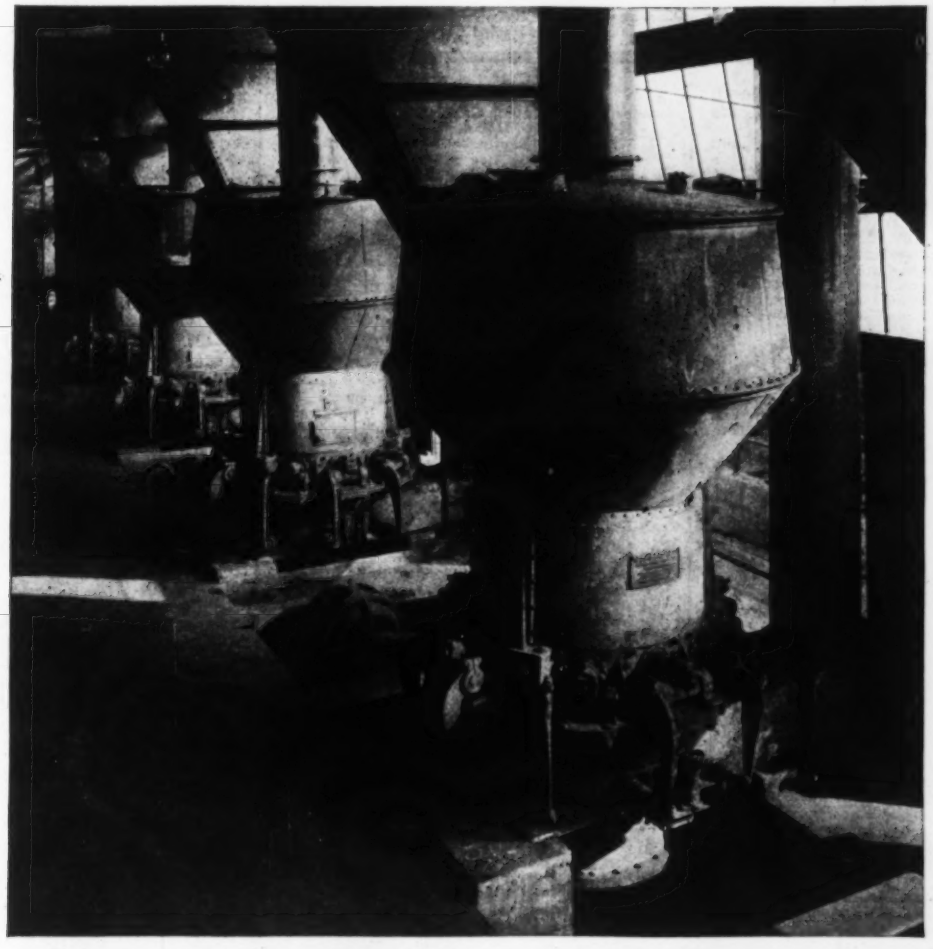
Carborundum Co. 22
Niagara Falls, N. Y.
Will exhibit the following: Physical Examples of Carbofrax Boiler Wall Construction of the Non-Perforated Air Cooled Type; Nygaard Water Wall type; Bernitz Air Cooled Wall; Carbofrax Faced Suspended Arch; Seymour Water Wall and Nygaard Unit Expansion Non Perforated Air Cooled Walls. Also various Carbofrax Brick, Special Shapes and Cement.

Carrier Engineering Corp'n 14A
750 Frelinghuysen Ave., Newark, N. J.
See Adv. Page 115
Will exhibit the latest developments in Air Conditioning, Refrigeration, Drying and Heating Equipment. The Weathermaker, the new home air conditioning system, will be exhibited in operation.

Carrier-Lyle Corp'n 14A
750 Frelinghuysen Ave., Newark, N. J.

Continued on page 78

IT DELIVERS AT ALL TIMES



FUEL OF UNIFORM FINENESS

Engineers know that a power plant, to operate efficiently, must use pulverized fuel of uniform fineness. The Bethlehem Pulverizer is the one machine that delivers at all times uniformly fine fuel. That is one reason why more and more plants are being equipped with it.

No amount of wear in the grinding elements can affect the ability of the Bethlehem Pulverizer to turn out a product of unvarying fineness. A system of heavy springs and levers maintains a uniform pressure between the rollers and the table tracks, and the grinding area remains the same, regardless of any degree of wear that may have occurred. Even after many years of service the Bethlehem Pulverizer will deliver fuel just as uniformly fine as the day it was installed.

It has many other advantages all of which are fully covered in Catalog J-1. Write for a copy today.

BETHLEHEM STEEL COMPANY

General Offices: Bethlehem, Pa.

District Offices: New York, Boston, Philadelphia, Baltimore, Washington, Atlanta, Pittsburgh, Buffalo, Cleveland, Detroit, Cincinnati, Chicago, St. Louis, San Francisco, Los Angeles, Seattle, Portland, and Honolulu

Bethlehem Steel Export Corporation, 25 Broadway, New York City, Sole Exporter of our Commercial Products.

See the Bethlehem Exhibit at the Power Show, New York City, Booths 70 and 71.

BETHLEHEM
PULVERIZER

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

Cash, A. W., Co. 273
4th & Eldorado Sts., Decatur, Ill.
Exhibiting Cash Standard Reducing and Regulating Valves.

Celite Products Co. 14
1320 So. Hope St., Los Angeles, Cal.
See Johns Manville (Inc.)

Centrifix Corp'n 214
830 Keith Bldg., Cleveland, Ohio.
Will exhibit purifying equipment for steam, vapor, gas and air, and a steam boiler Deconcentrator. Separation is by centrifugal means and is obtained without power and without rotating parts.

Century Electric Co. 626, 627
1806 Pine St., St. Louis, Mo.
Showing Motors and Fans. The main features of the exhibit are large Squirrel Cage Motors, and Multi-Speed motors. Also an announcement feature that Roth Brothers & Company are now a division of the Century Electric Company and some of their equipment will be exhibited.

Chicago Pipe Thread Mach. Co. 528
Racine, Wis.
Manufacturers of Pipe Threading Machinery.

Clements Mfg. Co. 563
601 Fulton St., Chicago, Ill.
Will exhibit a complete line of Clements Cadillac Portable Electric Blowers with various blowing and suction attachments and adaptations, all models recently redesigned and substantially improved.

Cleveland Worm & Gear Co. 92, 93
3264 East 80th St., Cleveland, Ohio
Exhibiting Worm Gear Reduction Units.

Clipper Belt Lacer Co. 265
974–1014 Front Ave., N. W., Grand Rapids, Mich.
The complete Clipper line, consisting of the various models of Clipper Belt Lacers, Belt Fasteners, Belt Cutters with safety features, and connecting pins, will be exhibited. The electrically operated Clipper Ship will also be shown.

Cochrane Corp'n 67
3142 N. 17th St., Philadelphia, Pa.
Will exhibit a self-contained Deaerator for preventing corrosion; a Multiport Back Pressure Valve; a low pressure Drainer; a Steam Purifier; A Discharger for draining it; a tandem One-Piece Steel Blow-Off Valve; V-notch Weir Recorder and an Acid Feeder.

Colson N. Y. Branch (Inc.) 611
7 East 19th St., New York, N. Y.
Will show samples of cast iron, pressed steel and forged steel Casters made up with bearings of any descriptions including plain bearing, ball bearing, roller bearing and with cast iron or forged steel, or wheels fitted with moulded rubber tires or moulded aluminum alloy tires.

Connery & Co. (Inc.) 43
2nd & Luzerne Sts., Philadelphia, Pa.
Will exhibit Breechings and Air Ducts constructed with Connery's Improved Expansion Stiffener, together with Connery's Improved Air Cooled Damper and Connery's Expansion Stiffened Stack Connection.

Connor, Wm. B. (Inc.) 467
369 Lexington Ave., New York, N. Y.
Exhibit will show the CONNOR Pumping and Direct Return Traps as well as the CONNOR Non-Return Corliss Valve Trap. Cross sectional samples of the various mechanisms used will be shown.

Conover—Mast Corp'n 445
420 Lexington Ave., New York, N. Y.

Consolidated Ashcroft Hancock Co. 60
Bridgeport, Conn.
Featuring the Power Control Valve, Pop Safety and Relief Valves, Bronze, Cast Steel and Forged Steel Hancock Valves, Recording Thermometers and Recording Gauges.

Consolidation Coal Co. 526, 527
15 Broad St., New York, N. Y.

Consolidated Gas Co. of N. Y. 7
130 East 15th St., New York, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

Booth

Cooper Hewitt Electric Co. (Inc.) 4
410 Eighth St., Hoboken, N. J.
Will exhibit Kon-nec-tors (mercury switches) and Neon Glow Lamps. The Kon-nec-tors will be in operation on sign flashers and an automatic pressure control. The Neon Glow Lamps will be in operation as indicator and pilot lights. In addition to the operating exhibit, various equipment will be shown in which Kon-nec-tors are used.

Crane Company 52
836 S. Michigan Ave., Chicago, Ill.
Exhibit will include new designs of Cast Steel Valves, and also a Forged Steel Valve for extreme pressure and temperature service. One very interesting part of the exhibit will be three valves on which various means for remote control are mounted. These controls are by electric motor, air motor and hydraulic cylinder. Exhibit also will include the general line of brass goods for usual commercial service.

Crane Packing Co 650, 651
1820 Cuyler Ave., Chicago, Ill.
See Adv. Page 113

Featuring an exhibit consisting of Metallic and Semi-Metallic Packings of Babbitt Foil, Aluminum, Copper-flexible in construction and suitable for steam, air, ammonia, hot and cold oil, hot and cold water, saturated steam, and superheat, CO_2 and other gases. Metallic packings for condensers, and models to show its application without ferrules. The New "John Crane" Universal Metal Gasket strip will be shown which requires no bolt holes, and which is universal for any flange, regardless of size.

Cutler-Hammer, Inc. 261, 262
12th & St. Paul Sts., Milwaukee, Wis.
Exhibiting Outstanding Developments in Motor Control consisting of: Across-the-Line Automatic Starters, Motor Operated Valve Control; the new C-H Unbreakable Resistor, the bulletin 9586 "AAA" small size Across-the-Line Automatic Starters, New Development in Elevator Control and Accessories, Motor Control for large Buildings, Control Apparatus for Marine Service, Electric Heating Units, Wiring Devices, etc.

Dampney Company of America 62
Hyde Park, Boston, Mass.
Will exhibit their complete line of APEXIOR Protective Coatings for metal surfaces and show the equipment that has been developed for applying same expeditiously to the internal surfaces of boiler, economizer and condenser tubes and other types of power plant equipment.

Dardelet Threadlock Corp'n 296, 297
120 Broadway, New York, N. Y.
See Adv. Page 107

Exhibiting in operation a bolt threader, various test specimens, samples of bolts and nuts and threaded parts, samples of taps, dies and chasers, exhibition of various uses of the Dardelet thread and samples of the Dardelet Thread as applied to various metals.

Davies & Thomas Co. 490
Catasauqua, Pa.
Exhibiting Castings, etc.

Davis Boring Tool Co. 263
St. Louis, Mo.
Division of the Larkin Packer Company, St. Louis, Mo. Manufacturer of Davis Improved Type "L" Micrometer Expansion Boring Tools, Multiple Head Boring Tools, Expansion Reamers, Plain and Expanded Block Type Bars and Cutters for car wheel, railroad, and general industrial boring.

Dean, Payne (Ltd.) 16
17 East 45th St., New York, N. Y.
(See Limitorque Corporation.)

Dearborn Chemical Co. 13
310 S. Michigan Ave., Chicago, Ill.
205 East 42nd St., New York, N. Y.
See Adv. Page 114

Will show samples of Boiler Feed Water Treatment, No-Ox-Id Rust Preventive, No-Ox-Idized Wrapper, Lubricating Oils and Greases, and Dearborn Cleaners. A new product developed during the past year is our No-Ox-Idized Asbestos Felt Wrapper.

De Bothezat Impeller Co. 423, 424
1922 Park Ave., New York, N. Y.
Will exhibit Disc Pressure Fans all sizes 8"–8'. Bifurcators, unit heaters of unusual design, Impeller Blowers, Disc Blowers, also

Booth

a demonstration of possibility of obtaining non-overloading characteristics and high static pressure with very high efficiency with a Disc Fan of Dr. G. de Bothezat's special design.

Dennis Engineering Co. 251
243 N. High St., Columbus, Ohio
Displaying Dennis Turbine Expansion Joints and L. R. First Pass Soot Blowers. Models and photographs will be on exhibit on each class of equipment.

deSanno, A. P., & Son 466
1615 McKean St., Philadelphia, Pa.
Will exhibit the Radiac Cut-Off Machines.

d'Este, Julian, Co. 250
Cambridge & Spice Sts., Boston, Mass.
Will exhibit complete line of CURTIS ENGINEERING SPECIALTIES which includes Pressure Reducing Valves and Steam Drainage Controls. Specimens of actual valves and traps will be shown mounted and in sectioned forms. New CURTIS TYPE T RETURN TRAP, D'ESTE THERMOSTATS, and Packless Excess Pump Regulator will be shown.

Detroit Seamless Steel Tubes Co. 229
Detroit, Mich.
Manufacturers of SEAMLESS STEEL TUBING for Railroads, Industrial Plants, and Marine boiler purposes and also manufacturers of SEAMLESS STEEL TUBING for all Mechanical purposes.

Detroit Stoker Co. 203–206
3rd Fl. (Gen. Motors Bldg.) Detroit, Mich.
Will exhibit a complete line of stoker equipment, including one Detroit Multiple Retort Underfeed Stoker, one Detroit Triple Retort Underfeed Stoker and one Detroit Junior Stoker, the latter two being in operation. Large size photographs and literature describing the Detroit Single Retort and Unistoker, Detroit Double Retort and Industrial Stokers will be displayed.

Diamond Chain & Mfg. Co. 320
401 Kentucky Ave., Indianapolis, Ind.
Mounted on two heavy tables will run Roller Chain Drives actuated by Electric Motors of standard speeds, showing the single and multiple strand chain. There will also be on display samples of the various special attachments which they manufacture. Also five models of Clark Flexible Couplings.

Diamond Expansion Bolt Co. 480
Garwood, N. J.
Exhibiting line of Expansion Bolts, Drills, Toggles, and other allied attachments. Will feature the Diamond Forge Twist Drill and Rubber Grip Holder; the Diamond Hammer Drive Anchor, the new nail expansion, Diamond Calking Anchor, etc.

Diamond Power Specialty Corp'n 16, 17
10340 Oakland Ave., Detroit, Mich.
Will exhibit various types of Soot Blower Heads. Will also show a new moving picture entitled COAL IS KING, which illustrates graphically the tremendous waste of coal and various ways and means of preventing same.

Dixon, Jos., Crucible Co 257
Wayne & Monmouth Sts., Jersey City, N. J.
See Adv. Page 102

Will show Graphite Products such as Flake Lubricating Graphite, Graphite Greases, Belt Dressing, Graphite Seal, Graphite Pipe Joint Compound and other miscellaneous Graphite Products.

Dodge Mfg. Corp'n 32
Mishawaka, Ind.
Manufacturers of Power Transmission Equipment—Bearings, Bushings, Friction Clutches, Shaft Collars, Countershafts, Shaft Couplings, Fly Wheels, Shaft Hangers, Gears, Pillow Blocks, Pulleys, Shafting, Sheaves, Sprockets, etc. Also Oil Engines, Conveyors, and Special Machinery.

Doehler Die Casting Co. 409
272 Lafayette St., New York, N. Y.
Will exhibit a complete line of standardized die cast stock gears, also a moving exhibit showing an assembly of such products, and comprising nearly 200 gears in action. A comprehensive selection of Bond Standard Stock Gears will also be shown.

Continued on page 80

"PARKER"

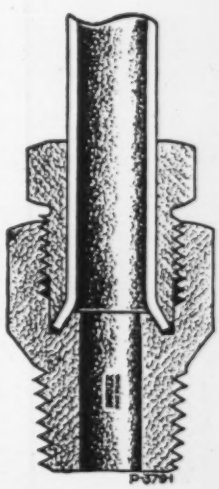
THREADLESS PLUMBING

IN power plants assures freedom from the expensive deficiencies of threaded joints.

PARKER TUBE COUPLINGS connecting PARKER seamless tubes of copper or steel—fabricated with PARKER Bending and Flaring Tools offers the only satisfactory solution of the instrument and similar small Power Plant piping problems.

In Aircraft and Steam Ships—Power Plants, Locomotives or Machine Tools—wherever severe service is encountered—there you will find PARKER Threadless Plumbing—installed securely and permanently with minimum labor and saving with complete satisfaction. Power Plant instruments are dependent for the accomplishment of the purpose for which they are purchased, upon secure piping—PARKER Threadless Plumbing assures satisfactory instrument performance.

PARKER APPLIANCE CO. Data sheets are helpful to the designer, constructor or operator. Send for literature and sample Tube Coupling.



THE PARKER APPLIANCE CO.

10320 BEREA RD., CLEVELAND, OHIO
U. S. A.

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* **Booths No. 200 to 348—Second Floor—*Diagram on Page 108***
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Domestic Stoker Co. ..... Booth 217, 218
7 Dey St., New York, N. Y.
Will exhibit Domestic Stokers known as the Electric Furnace-Man. One Stoker will be in actual operation, showing how Anthracite coal is automatically fed to the fire-pot and how ashes are automatically removed to sealed container.

Dri-Steam Valve Sales Corp'n 3F
565 Fifth Ave., New York, N. Y.
Will exhibit full size cut models of Dri-Steam Valves, in globe angle and non-return types, for all pressures, showing separating and steam drying device. Will show new graduating radiator inlet valves—packed and packless.

Dunham, C. A., Co. 235, 236
450 East Ohio St., Chicago, Ill.
Products Shown—Operating Units of Dunham Differential Vacuum Heating System, Vacuum Pump and Control equipment.

Dunn, Struthers (Inc.) 520
1130 Race St., Philadelphia, Pa.
Will exhibit "Dunco" relays, Thermostatic Control, "Dunco" Melting Pots and Ladles, and Insulating Beads. The main feature will be the relay switches.

Durametallic Corp'n 408
806 Cobb Ave., Kalamazoo, Mich.
Will exhibit not only their regular line of Durametallic Packing and Gaskets but some vitally important developments, viz.: Durametallic Elastic Core Packing, and Durametallic Style 1100, which is Dura Plastic within a metal wrapper in ring form.

Duriron Co. (Inc.) 6
Dayton, Ohio
Will show a No. 80 Duriron Self-Priming Pump, a 6″ Duriron fan and a Duriron Acid Proportioning Pump, all in operation. In addition to this, have on display Duriron Valves, Cocks, Pumps of other models, etc. Also showing samples and fabricated parts of "Durimet," our new acid-resisting steel.

Ediplate Corp'n 410
Orange, N. J.
Exhibit will be limited exclusively to Seamless Floats made by a process developed at the Edison Laboratory. This year as a new departure, are showing a one-piece demonstrate floats on vibration test as well as floats finished in various special metals for resistance to various chemicals.

Edward Valve & Mfg. Co. 506
East Chicago, Ind.
See Adv. Page 109

Products to be shown will include a 10″ 1350 lb. W.S.P. Cast Steel Globe Non-return Valve, with Limitorque motor control, intended for the new South Amboy station of the Jersey Central Power & Light Company; a 2½″ model end thrust ball bearings, impactor handwheel, and the sectionalized so as to show the features of construction; forged steel globe stop valves for 400–600 lb. and 900–1350 lb., W.S.P.

Electric Storage Battery Co. 428
Allegheny Ave. at 19th St., Philadelphia, Pa.
Exhibit will consist of Exide Batteries and Exide-Ironclad Batteries for industrial truck, street truck and locomotive service, as well as batteries used for oil switch and emergency lighting. Batteries with cells cut away to show construction will be included.

Electrical Manufacturing 561, 562
461 Eighth Ave., New York, N. Y.
Display will be devoted principally to ELECTRICAL MANUFACTURING, featuring its value to electrical manufacturers through both its advertising and editorial pages.

Electrical Record 561
461 Eighth Ave., New York, N. Y.

Ellison Draft Gage Co. 44B
214 West Kinzie St., Chicago, Ill.
Will exhibit: Ellison Draft Gages, Tube and Pointer types. New features—scale reading gas flow; Ellison U-Path Steam Calorimeter having the accuracy of 20 within the theoretical temperature; and Ellison-Pitot tubes.

Engelhard, Chas. (Inc.) 74
90 Chestnut St., Newark, N. J.
Will have a small furnace in operation with the pyrometers and a special thermocouple to give an average temperature reading. The Electric Resistance Thermometer will be placed in the furnace to check the pyrometer and show also the relative accuracies.

Engineer Company 18
17 Battery Place, New York, N. Y.
Products shown will be ENCO Baffle Walls, ENCO Combustion Control and ENCO Oil Burning Equipment. Showing for the first time a very large combination gas and oil burner. This is a new development, and it is the largest oil burning equipment that has ever been developed.

Engineering: (Ltd.) 607
35–36 Bedford St., Strand, London WC₂ England
Recent copies of the weekly publication "Engineering" (London) will be available. Also copies of "The Engineering Directory." Advertising rates, brochures giving specimens of two color printing, and other data will be available.

Engineering Publications, Inc 2N
1900 Prairie Ave., Chicago, Ill.
At this booth the engineer will find valuable information, both printed and verbal, pertaining to his every day problems as well as to those of the future in Heating, Piping and Air Conditioning field.

Engineering & Finance ..... B Main Floor
551 Fifth Ave., New York, N. Y.
A monthly publication, founded in 1919 as Combustion, renamed in 1929, devoted to the interest of the combustion engineer and utility executive.

Engineers Book Shop 28B
159 E. 44th St., New York, N. Y.
Will exhibit a selection of the best Technical Books that have been published since the last Power Show together with such standard works as are always needed. There will be books and pamphlets on machinery; power, gas, electrical, steam; aeronautics; mathematics; equipment of all kinds; pure and applied physics and chemistry; handbooks, etc.

Equipment & Supply Co. (Inc.) 402
51 Madison Ave., New York, N. Y.
Exhibiting the AUTO-SHIFT Drafting Table with automatic counterbalanced action controlled from two pedals. Also steel furniture and plan files. Also an improved drafting machine.

Erie City Iron Works 91
Erie, Pa.
Will have on exhibit a displayer describing each of their products and showing various installation features. Equipment to be featured: Erie City Two Drum Heat Boiler; Erie City UNITYPE Pulverizer; Erie City Three Drum Boiler fired by various methods; Erie City Cross Drum Boiler; Erie City VORTEX as applied to H. R. T. Boiler and Erie City Steel Heating Boiler.

Ernst & Co. 76
44 Oakland Terrace, Newark, N. J.
Will exhibit Water Level Gauges, inclined and vertical, particularly gauges for high pressures.

Everlasting Valve Co. 41
1 Exchange Pl., Jersey City, N. J.
Main features of the Exhibit: Regular Everlasting Valves; Everlasting's Companion Angle Valve; Everlasting Duplex Blow-Off Unit.

Fairbanks Co. 259
Broome & Lafayette Sts., New York, N. Y.
Exhibit consists of display of BRONZE AND IRON VALVES, GLOBE, ANGLE, GATE AND CHECK pattern. Also will feature the FAIRBANKS SPHERO VALVE. DART UNIONS, FITTINGS and DART FLANGES will also be exhibited.

Falk Corp'n 540, 541
Milwaukee, Wis.
Will exhibit Speed Reducers, Gears and Flexible Couplings. Shown in operation will be a pumping outfit which is used to show the Falk Flexible Coupling in operation. This device is so contrived as to draw the coupling considerably out of alignment and also affords an opportunity of demonstrating the coupling's ability to allow free end float.

Fawcus Machine Co. 605
2818 Smallman St., Pittsburgh, Pa.

Fire King Stoker Co. 8
Indianapolis, Ind.
Will exhibit Fire King Stoker complete which will be in operation.

Fisher Governor Co. 610
2000 Fisher Bldg., Marshalltown, Iowa.
Will display Reducing Valves, Pressure Regulators, Pump Governors, Steam Traps, Liquid Level Controllers, Float Valves, and also will display two or three different types of new pilot operated pressure controls of recent development. Gas Regulators will also be included.

Fisher Publishing Co. 609
299 Madison Ave., New York, N. Y.

Fitzgibbons Boiler Co. (Inc.) 254, 255
570 Seventh Ave., New York, N. Y.
Exhibiting several sizes of Fitzgibbons Steel Heating Boilers. The boilers on exhibition will be replicas of the large size Fitzgibbons Power and Heating Boilers.

Foley Manufacturing Co. 451
9 Main St., N. E., Minneapolis, Minn.
Exhibiting the Foley Automatic Saw Filer — The Three Way Machine, files and joints in one operation, hand, band, and circular saws.

Foster Engineering Co. 84
109–113 Monroe St., Newark, N. J.
Exhibiting Pressure Regulators, Pump Governors, Boiler Stop Valves, etc., of standard and also of steel construction for extreme pressures and temperatures. Many of the "Valves" are cut in section, to show the internal parts. The Foster Sight Flow Box will be included.

Foxboro Co. (Inc.) 403, 404
Foxboro, Mass.
Featuring Foxboro Steam Flow Meter. Also will display a large model of this instrument operating and illuminated in several colors to show the simple, easy and accurate operation of the Foxboro Steam Flow Meter. In addition will display a steel Gaugeboard on which will be mounted a typical Foxboro power plant installation of Recording and Indicating Gauges, Thermometers, Meters and Controllers.

Frank, O. E., Heater & Engrg. Co. (Inc.) 10
20 Milburn St., Buffalo, N. Y.
Will exhibit a 3 Unit Frank Heat Re-Cleaner full size. Will be installed exactly in actual installation, with all the necessary piping. The Re-Claimer is designed to reclaim heat from siled waste fluids ordinarily discharged to the sewer when hot by causing to flow through the Re-Claimer cold clean fluid to be used in process.

Fuller-Lehigh Co. 54
Fullerton, Pa.
See Adv. Pages 100, 101

Exhibiting for the first time the grinding elements of their new Fuller-Lehigh, Type B, Table Mill. An actual bottom corner section of a Bailey Water-Cooled, Slag-Tap Furnace will also be exhibited. This corner section will show in detail the construction of this type of furnace, including the tube, block, tie-row and air-cooled floor details, also the method used to seal the furnace against air infiltration. Included with this model will be samples of the slag from a furnace of this type. A displayor will be used to show drawings and photographs of approximately 50 Fuller-Lehigh Installations of Pulverized-Coal Equipment and Water-Cooled Furnace Walls. Pertinent facts regarding each of these installations will be given on display cards.

Fulton Sylphon Co. 219, 220
Knoxville, Tenn.
Exhibiting Sylphon Self-contained Thermostats for controlling liquid and air temperatures. Regulators for hot water and process tanks, drying rooms and heating ducts. Individual Thermostatic Radiator Valves, Mill-room Thermostats. Self-contained Steam and Water Mixers. Pressure Reducing Valves. Packless Expansion Joints for heating risers.

Fyre-Freeze Corp'n 292
17 West 46th St., New York, N. Y.
Exhibiting Fyre-Freeze Carbon Dioxide Portable Extinguishers and Extinguishing Systems.

G&G Atlas Systems (Inc.) 86–88
543 West Broadway, New York, N. Y.
G&G Atlas Pneumatic Dispatch Tubes will be in operation under such conditions as would exist in large office buildings or industrial plants, so that engineers can see how routine documents such as mail, telegrams,

Continued on page 82

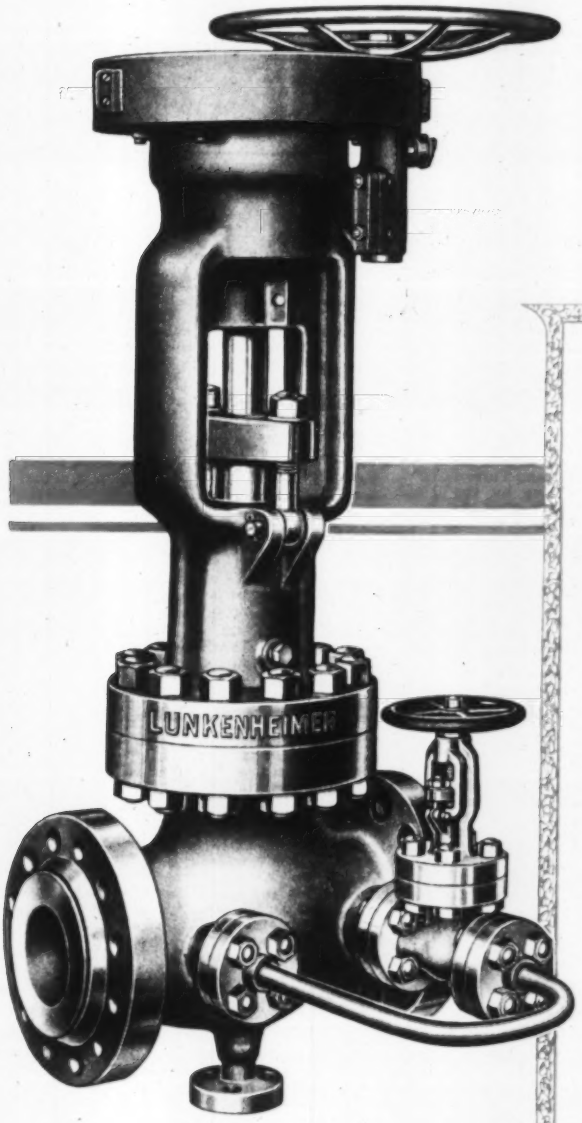
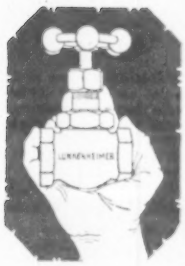


Fig. 1655
6 in. 1350 Lb. W. S. P.
Steel Globe Valve
with Exterior By-pass



VISIT OUR EXHIBIT
POWER SHOW

56

LUNKENHEIMER

1350 LB. W.S.P.–775°F STEEL VALVES

4 In. and Larger
were supplied for the
Initial Installation
at the

DEEPWATER PLANT

of

THE AMERICAN GAS & ELECTRIC CO.
and
THE UNITED GAS & IMPROVEMENT CO.
DEEPWATER POINT, N. J.

Stevens & Wood, Inc.
Engineers and Constructors

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO BOSTON PHILADELPHIA
PITTSBURGH SAN FRANCISCO . LONDON
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

15-50-4

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

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Booths No. 400 to 569—Third Floor—*Diagram on Page 110*

Booth

samples, production orders, etc., can be collected and distributed among scattered departments at a speed and efficiency which cannot be obtained through the use of human messenger service.

G. D. S. Shearing & Punching Mch. Co. 244, 245
Hagen Germany

Ganschow, Wm., Co. 605
1000 West Washington Blvd., Chicago, Ill.

Garlock Packing Co 545, 546
Palmyra, N. Y.
See Adv. Page 95

Exhibit will consist of a line of Garlock Asbestos, Rubber, Fibrous and Metallic Packings and Gaskets for every industrial requirement.

Gears & Forgings (Inc.) 604, 605
3130 Woodhill Road, Cleveland Ohio
See Adv. Page 96

Exhibiting Planetary Worm and Herringbone Speed Reducers; all kinds and sizes of Gears; Drop and Smith Hammered Forgings; and Van Dorn 2 Speed Axles.

General Electric Co. 4, 5
Schenectady, N. Y.
Exhibit will feature Synchronous Motors. In addition there will be exhibits of switchgear and a Photo Electrically Controlled Door.

General Fire Extinguisher Co. 309
420 Lexington Ave., New York, N. Y.
Manufacturers of fire extinguishing equipments.

General Insulating & Mfg. Co. 414
Alexandria, Ind.
Exhibiting the following: Gimco Rock Wool Flexfelt for Heat, Cold and Sound Insulation, Pipe Covering for heat and cold insulation, Rock Wool Corkboard and Loose and Granulated Rock Wool.

General Stoker Corp'n 27
270 Lafayette St., New York, N. Y.
Showing Model F General Stoker, underfeed type; Dump Grates; capacity to 1250 pounds of coal per hour; eight positive speeds; all controls localized at front of unit; silent in operation.

Gibson & Halpern 606
15 Park Row, New York, N. Y.
Representing: Imperial Die Casting Co.

Gillis & Geoghegan (Inc.) 86–88
543 W. Broadway, New York, N. Y.
Electric and Hand Power Ash Removal Equipment will be exhibited and in operation under conditions such as exist in a modern school, office, or similar building, giving the engineer an opportunity to see method by which the usual anger in Sidewalk Hoistway Opening is eliminated.

Girtanner Engineering Corp'n 212
122 Greenwich St., New York, N. Y.
Will exhibit Ash Handling Equipment, covering pipe conveying, including Pneumatic, Hydraulic, Steam Vacuum, Steam Jet, Baffle Wall Conveyors, Ash Storage Tanks, Ash Pit and Furnace Doors.

Gordon, James T., Co. 92, 93
11 Park Place, New York, N. Y.
Representing: Andale Company, Cleveland Worm & Gear Co., W. H. Nicholson & Co.

Green Fuel Economizer Co. 73
Beacon, N. Y.
Will exhibit: Air Preheater, Forced Draft Fan, Cindertrap, and Dustrap.

Grinnell Co. (Inc.) 308–311
216 North Exchange St., Providence, R. I.
Will feature Thermoliers, Grinnell's recently developed and widely successful unit heater; Grinnell Adjustable Hangers; Grinnell Power Piping Hangers; and Grinnell Triple XXX line of Piping for Super Power work.

Gun-Fil Corp'n 429
112 So. 16th St., Philadelphia, Pa.
Will exhibit Gun-Fil Lubricators, Lubricating Equipment, Lubricants, Lubricating Systems and applications for use on industrial, automotive and aircraft equipment, capable of handling oil or grease.

Hagan Corporation 21
Pittsburgh, Pa.

Hahn Engineering Co. 648, 649
Lancaster, Pa.
Exhibiting: Steam-Jet Ash Conveyors; Cast Iron Sectional Ash Tanks and Coal Bunkers; Lined Cast Iron Sectional Ash Hoppers; Complete Elbow Set showing

Booth

Jet-Elbow, Rebound-Fitting and Corundum-inserted Liners; Model of Octagonal Cast Iron Tank; and Model of Side-Disch. Lined Ash Hopper.

Hall Laboratories 21
Pittsburgh, Pa.
Will exhibit samples of boiler metal which have failed in service through cracking. Information will be available at the booth regarding the progress of studies of "Caustic embrittlement" and allied phenomena. Samples of steel will be tested to destruction.

Hanson-Whitney Machine Co. 263
169 Bartholomew Ave., Hartford, Conn.
Manufacturers of Thread Milling, Vertical Die Shaping and Centering Machines; also Taps, Hobs, Precision Screws and Thread Gages all finished *after* hardening by the "Hanson Process," guaranteed perfect in thread form and accurate in lead within 0.0001" per inch.

Hanson & Yorke Co. 511
88 Warren St., New York, N. Y.
Representing: W. O. Barnes & Co., and Sumet Corporation.

Harbison-Walker Refractories Co. 58
Farmers Bank Bldg., Pittsburgh, Pa.
Will exhibit various types of refractories including fire clay, silica, chrome and magnesite; also fire-bond high temperature cement and Thermolith high temperature cement.

Hardinge Co. (Inc.) 30
122 East 42nd St., New York, N. Y.
Working models of the Hardinge Coal Pulverizer and of a Constant Weight Feeder will be exhibited. The Coal Pulverizer has some new features which have been developed this year, and the Constant Weight Feeder is a new machine.

Hartzell Propeller Co. 624
Piquia, Ohio
Will exhibit Charavay Exhaust Ventilating Fans and Blowers. Featuring Single-blade Fans, Multiblade Fans, Two Propeller Fans, Extension Shaft Fans, Blowers, and Kool Blast Fans. Also showing one of their Theater Fans.

Hazard Insulated Wire Works 619
Pittsburgh, Pa.

Heating, Piping & Air Conditioning 2N
110 East 42nd St., New York, N. Y.

Hisey-Wolf Machine Co. 340, 341
Cincinnati, Ohio
Direct Motor Driven Electric Drills, Grinders and Buffers; Motor in the base Tex-Drive Buffing and Polishing Machines; and High Speed TexDrive Snagging Grinders.

Hoffman Specialty Co. (Inc.) 437, 438
Waterbury, Conn.
Will show a complete line of Hoffman Venting Valves and Controlled Heat Vapor Specialties. The feature of the exhibit will be a Hoffman Economy Vacuum Pump and Hoffman Economy Condensation Pump in actual operation. Will also show a Hoffman Moto-Heater. This heater will be shown in actual operation. Also featuring the Hoffman Thermador, an electric heater.

Houghton, E. F., & Co. 532–534
240 W. Somerset St., No. Phila., Pa.
Exhibit will feature Houghton Power Transmission and Lubricating Service. The Houghton Pullmeter will be one of the main attractions.

Howell Elect. Motors Co. 615
Howell, Mich.
Will exhibit exploded view of Polyphase Motor, operating exhibit of reversible Brush-Less Single Phase Motor, operating exhibit of lower fan with special fan motor and a totally enclosed self ventilating motor with across-the-line starting equipment.

Hurych, Jerome W., Mfg. Co. 401, 402
2431 Kindred St., Astoria, L. I., N. Y.
Exhibiting the Automatic Drafting Table, designed to facilitate and expedite drafting, preserve the draftsman's energy, avoid any physical strain and fatigue, and thus to convert the strenuous work.

Hutchinson Mfg. Co. 407
255 Lafayette St., New York, N. Y.

Huyette, Paul B., Co. (Inc.) 81, 82
5 S. 18th St., Philadelphia, Pa.
Will exhibit: PBH Tiltview and Straight Water Gauges, PBH Weighted Gauge Cocks, Reliance High Pressure Water Columns and Water Gauges, Hays Boiler Panel in miniature containing CO Recorder Draft Gauge

Booth

and Cochrane Flow Meter, as well as other equipment for the Boiler Plant.

Ilg Electric Ventilating Co. 277, 278
2850 N. Crawford Ave., Chicago, Ill.
Will exhibit a Unit Heater and will feature a direct connected multiblade blower with 3 phase motor, using the new Ilg variable air controller for varying the air delivery. This device provides great peller fan and other miscellaneous apparatus will also be displayed.

Illinois Engineering Co. 82, 83
Racine Ave. at 21st St., Chicago, Ill.
Will exhibit cut section Reducing Valves, Stop and Check Valves, Back Pressure Valves, Radiator Traps and Modulating Valves, also show glass Steam Trap in actual operation under steam. Also demonstrate Illinois Zone Heat Control for Buildings.

Imperial Coal Corp'n 36
342 Madison Ave., New York, N. Y.
Exhibit will be one of standardized bituminous and semi-bituminous coals as produced at mines owned and operated by the Imperial Coal Corporation.

Industrial Controller Co. 613
30 Church St., New York, N. Y.
(See Square D Co.)

Industrial Power 3E
608 S. Dearborn St., Chicago, Ill.

Instant Water Heater Sales Div. 274
Chicago, Ill.

Insulating Products Corp'n 25, 25A
280 Madison Ave., New York, N. Y.
Manufacturers of Insulating Products.

International Engineer 427
6334 Yale Ave., Chicago, Ill.

International Nickel Co. (Inc.) 9
67 Wall St., New York, N. Y.
Will exhibit Monel Metal and pure Nickel in commercial forms such as rods, sheet, tubes, strip, wire, forgings, castings, etc. Also displaying samples of finished vital parts of power plant equipment as produced by leading manufacturers in this field.

Invincible Vacuum Cleaner Mfg. Co. 639, 652
Dover, Ohio
Will show a complete line of portable Vacuum Cleaners, a new Industrial Model for factories of all kinds, as well as Heavy Duty Portable Models for office buildings, hotels, theatres, department stores and public buildings of all kinds.

Irving Iron Works Co. 439, 440
Dutchkill Creek & 3rd St., Long Island City, N. Y.
Will exhibit "IRVING SUBWAY" Steel Mesh Flooring and "SAFSTEPS" of the new "IRVICO" design, featuring the new development of CONTINUOUS Flooring and ARMORING by virtue of the very latest development, namely the "IRVING STREAMLINE" SPLICE. Also "IRVING UNIFLED" Reinforcement and Armor for concrete slab construction and "IRVING SAFCROSS" which is a new application of "IRVING UNIFLED."

Jenkins Bros. 90
80 White St., New York, N. Y.
See Adv. Page 125

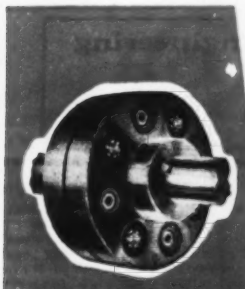
Exhibiting Bronze and Iron Valves of globe, angle and gate types for standard and extra heavy pressure; Rapid Action for water service; Radiator valves of standard types; Mechanical rubber goods of all kinds including sheet packing, and Moncrieff Scotch Gauge Glasses. In addition will feature a 20" Motor-Operated Iron Body Valve.

Johns-Manville (Inc.) 14
292 Madison Ave., New York, N. Y.
See Adv. Page 103

The structural effect of their exhibit will be built of J-M Transite and will consist of three shadow boxes. The center panel will show their complete insulation service to industry. This remarkably complete service was made possible by the acquisition of Celite Products Company and The Banner Rock Company during the past year. One panel will be devoted to their packing, and another to their building materials.

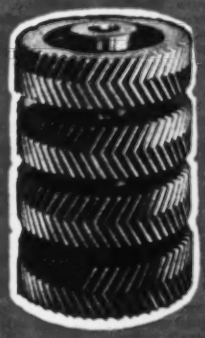
Jones, W. A., Foundry & Machine Co. 300, 301
4400 W. Roosevelt Road, Chicago, Ill.
Will show their Worm Gear, Herringbone

Continued on page 84

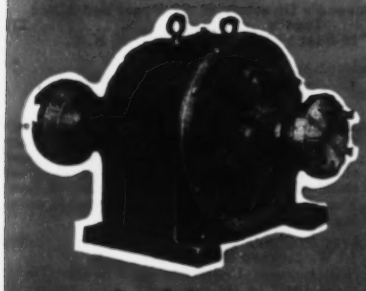


Phillie Coupling

Worm Reducer



Continuous Tooth Herringbone Gears



Spur Reducer

See the Complete line of Philadelphia SPEED REDUCING UNITS

(ONE NAME-ALL TYPES)

Couplings and Gears at Booth 13

The Philadelphia line of products is made in our new and most modern plant, which contains all the latest equipment for the production of power transmission products, with speed and precision.

NOTE THIS—Philadelphia Speed Reducers are made in ALL TYPES TO MEET EVERY DRIVE REQUIREMENT,—also that Philadelphia Gears are still maintaining their reputation for "delivery when promised,"—plus 100% inspection which assures "no rejects."

PHILLIE GEAR

Power Saving Products

GEARS: Spur, Worm, Herringbone, Internal, Bevel, Miter, Intermittent, Spiral, Helical, Continuous Tooth Herringbone Gears.

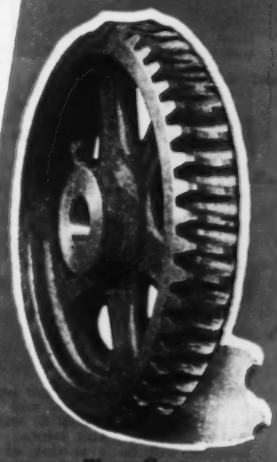
NON-METALLIC PINIONS: Fabroil, Textolite, Rawhide.

Ground Thread Worms.

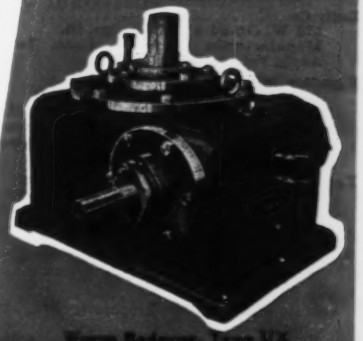
Whitney Silent and Roller Chains, Sprockets, Flexible Couplings, Universal Joints, Racks, Ratchets and Pawls, and a complete line of gear driven—

SPEED REDUCING UNITS

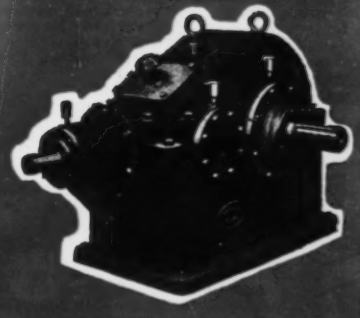
Fabroil Gear



Worm Gear



Worm Reducer, Type UX



Spiral-Bevel Herringbone Reducer

Main Office and Plant Erie Ave. and G St. Phila., Pa.

PHILADELPHIA GEAR WORKS

Manufacturers of Industrial Gears and Speed Reducing Units

PHILADELPHIA, PENNA.

Branch Sales and Engineering Offices

New York, 12 E. 41st Street Detroit, Donovan Bldg. Pittsburgh, Pa., Farmer's Bank Bldg.

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

and Spur Gear Reducers, and laying particular stress on their new Herringbone machines.

Justus Steam Trap Co. 325
Napanoch, N. Y.
Showing the improved "Justus Steam Trap" in operation. Also the different sizes from ½" to 2". The Ballancer and float valve have been combined into one unit.

Keating, E. F., Pipe Bending Co. 229, 230
Hartford, Conn.
Showing Pipe Bends, Welded Headers, Van Stone Joints, Pipe Coils, Seamless Steel Boiler Tubes, Toncan Seamless Iron Boiler Tubes and Valves.

Keller Mechanical Engrg. Corp'n 644, 647
68 Washington St., Brooklyn, N. Y.
Showing Kellerflex Flexible Shaft Equipment, Bench Machines, Suspended and Portable Types. Also new 1 H. P. Machine with balanced head and safety devices, Reciprocating Filing Attachment, Screw Driver, Right Angle Disc, Polishing Equipment, etc.

Kellogg, M. W., Co. 47
225 Broadway, New York, N. Y.
See Adv. Page 105

Will exhibit various of their products manufactured by the forge and hammer lap welded process, as well as various types of flanges, gaskets, and joints. Of particular interest will be a section of a forge and hammer lap welded boiler drum.

Kelly Co. 274
372 W. Grand Ave., Chicago, Ill.
Manufacturers of Globe, Gate, Jet, and Angle Valves.

Kempton Mfg. Corp'n 629
148 West 23rd St., New York, N. Y.
Exhibiting E-Z Bolt Anchors, Electric Clocks and Electrical Testing Instruments. Demonstration of their E-Z Bolt Anchors will be made every day.

Kennedy-Van Saun Mfg. & Engrg. Corp'n 23
2 Park Ave., New York, N. Y.
One of the main features of this exhibit will be a "Scene-in-Action" picture (animated scene) of their Air-Swept Tube Mill pulverizing coal and automatically firing the furnace of a boiler with this type fuel.

Keystone Lubricating Co. 3
21st Clearfield & Lippincott Sts., Philadelphia, Pa.
Will exhibit the new Keystone Pneuma-Lectric Lubricating system. This system is controlled by an electric clock and operates fully automatically. Units of Keystone Safety Lubricating System, Keystone Grease Cups, Pressure Fittings and various Keystone Lubricants will be shown.

Keystone Refractories Co. 11
120 Liberty St., New York, N. Y.
The following will be exhibited: DURASTIX Firebrick Cement; GRUNDUMS AND—granular refractory material; STEEL VENEER—granular refractory material and KEYSTONE REFRACTORY SPRAYER—an apparatus designed to "shoot" premixed materials on furnace walls.

Kidde, Walter, & Co. (Inc.) 292, 293
140 Cedar St., New York, N. Y.
Will exhibit a Lux System of the type that is being used to protect electrical and inflammable liquid fire hazards in industrial and public utility properties. A Lux Portable Extinguisher will also be shown.

Kieley & Mueller (Inc.) 281, 282
34 W. 13th St., New York, N. Y.
Exhibit consists of the principal items of their manufacture for use in the control of pressure in Power plants and Heating Systems. Various types of pressure Reducing Valves will be exhibited, also Back Pressure Valves, Damper Regulators, Steam Traps and Temperature Regulators.

Kilsoot-Carbocide Co. (Inc.) 3N
1834 Broadway, New York, N. Y.
Exhibiting "Kilsoot" and "Carbo-Cide," which cleans parts of boiler plants inaccessible to manual labor while plant is in operation.

King Refractories Co. (Inc.) 95
1715 Niagara St., Buffalo, N. Y.
Will exhibit High Temperature Refractories and Monolithic Baffle Construction.

Booth

Kings County Lighting Co. 7
6740 Fourth Ave., Brooklyn, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

Kissick-Fenno Co. (Inc.) 19
15 Park Pl., New York, N. Y.
Representing: Northern Equipment Co.

Klingerit (Inc.) 317
16 Hudson St., New York, N. Y.
Will exhibit Steam and Power Specialties for plant equipment including the High Pressure Klinger Seatless Piston Valves, Steel Reflex Gauges up to 1800 lbs. pressure, and the Original Klingerit Asbestos Sheet Packing.

Korfund Co. (Inc.) 554
235 E. 42nd St., New York, N. Y.
See Adv. Page 95

Will exhibit their natural cork base and VIBRO DAMPER in operation under the Troy Engine.

Kraissl Company 430
23 East 26th St., New York, N. Y.
Will exhibit following types of pumping equipment: Fuel Oil Pumps, Rotary Liquid Pumps, Turbine Pumps, Small Capacity Centrifugal Pumps, Vacuum Pumps, Rotary Compressors, and Strainers.

La Bour Co. 31
Sterling Ave., Elkhart, Indiana
There will be on exhibit, a self priming pump operating with glass suction line and equipped so as to show the manner in which this pump actually handles air.

La Favorite Rubber Mfg. Co. ..... 210 A-B-C
Hawthorne, N. J.
Will exhibit a general line of Mechanical Rubber Goods, such as: Gaskets, Diaphragms, MARVEL Packings, MARVEL Gauge Glass Washers, and moulded rubber specialties of every description.

Lancaster Iron Works (Inc.) 648
Lancaster, Pa.
Manufacturers of Agitators, Autoclaves, Smoke Breechings, Coal and Ash Bunkers, Iron Castings, Oil Condensers, Steel Converters, Rotary Coolers, Digesters, Hydraulic Dredges, Dryers, Evaporators, Filters, Coal and Ash Handling Systems, Welded Headers, Kettles, Kilns, Mixers, Vacuum Cans, Riveted and Welded Pipe, Special Machinery, Steel Stacks, Steel Plate Construction, Stills, Tanks, Contract Machine Work, etc.

Lead Lined Iron Pipe Co. 10
Wakefield, Mass.
Products shown are: "Wakefield" galvanized Amalgamated Lead Lined Pipe, Fittings, etc. for hot and cold water, service connections, etc.; "Wakefield" Amalgamated Acid Resisting Lead Lined Pipe, Flanges, Flanged Fittings, Flanged Valves, etc., for use on acids and other corrosive liquors; "Wakefield" Amalgamated Tin Lined Pipe, Fittings, Valves, etc., lined with pure block tin for use on carbonated and distilled water, syrups, fruit juices, or wherever else a highly sanitary pipe is required; "Wakefield" Hard Lead Pipe, Fittings, Valves, Coils, etc.; and "Wakefield" Lead Lined and Lead Covered Pumps.

Leavitt Machine Co. 528
16 East River St., Orange, Mass.
Exhibit will be the complete line of Dexter Valve Reseating Machines. The line includes machines for reseating gate valves, machines for refacing pump valve seats, and machines for reseating tank car outlet valves. Practical demonstrations of these various machines will be made.

Leeds & Northrup Co. 20
4901 Stenton Ave., Philadelphia, Pa.
Featuring special displays of Generator Field and Stator Temperature Recorders, Metered Combustion Control Apparatus and Automatic Frequency Control Apparatus. Will also exhibit Condenser Leakage Recorders, Testing Sets, Acidity Measuring Apparatus, Temperature Indicators, Recording Pyrometers and Thermometers.

Leslie Co. 535
Lyndhurst, N. J.
Products to be shown: Pressure Regulators,

Booth

Reducing Valves, Pump Pressure Regulators, Excess Pressure Regulators, Temperature Regulators, Relief Valves, and Self Cleaning Strainers. All devices with wearing and working parts renewable and made of stainless steel, nickel alloy and high pressure bronze.

Lewis Welding Company 323, 324
46 Carleton Street, Cambridge, Mass.
Will exhibit specimens of electric welding as applied to the piping industry and photographs of installations featuring all welded construction. (In conjunction with R. H. Baker Co.)

Limitorque Corporation 16
17 East 45th St., New York, N. Y.
Will exhibit styles of Limitorque Valve Control apparatus suitable for the operation of high pressure steam and water valves. Also Electric Damper Control. Also Centralized Valve Control Switchboard for the remote operation of valves, as well as an Electrically operated weather man.

Linde Air Products Co. 334, 335
30 East 42nd St., New York, N. Y.
A complete line of welding and cutting equipment will be on display including a full range of cutting and welding blowpipes. Prest-O-Lite acetylene and Linde oxygen, Union Carbide and Carbic in drums, and various welding accessories will also be shown. A feature of the exhibit will be the first showing of the new Oxweld Type W-17 Low Pressure Welding Blowpipe. Of particular interest to power plant engineers will be a full size oxwelded power plant piping special which shows various details of oxwelded construction.

Link-Belt Co. 285-287
300 West Pershing Rd., Chicago, Ill.
See Adv. Pages 99, 123

Will exhibit their line of Link-Belt Silent Chain Drives, Finished Steel Roller Chains, Link-Belt Herringbone Speed Reducers (Sykes tooth form), and other interesting products for the positive and efficient transmission of power.

Liquidometer Co. (Inc.) 630
3161 Skillman Ave., Long Island City, N. Y.
Will show a complete line of "Direct" and "Remote" Reading Tank Contents Gauges, including new Scale gauge for measuring by weight, liquid stored in large tanks, and new line of Aircraft gauges.

Little, Wm. P., Co. The 624
Stratford, Conn.

Lockwood's Directory of the Paper and Allied Trades 521
10 East 39th Street, New York, N. Y.

Lunkenheimer Co. 57
Cincinnati, Ohio
See Adv. Page 81

The main feature will be display of a 6 inch Cast Steel Outside Screw and Yoke Globe Valve with By-pass; To facilitate operation, the handwheel is mounted on an auxiliary shaft which is geared to the main valve stem. The Valve is designed for 1350 pounds working steam pressure.

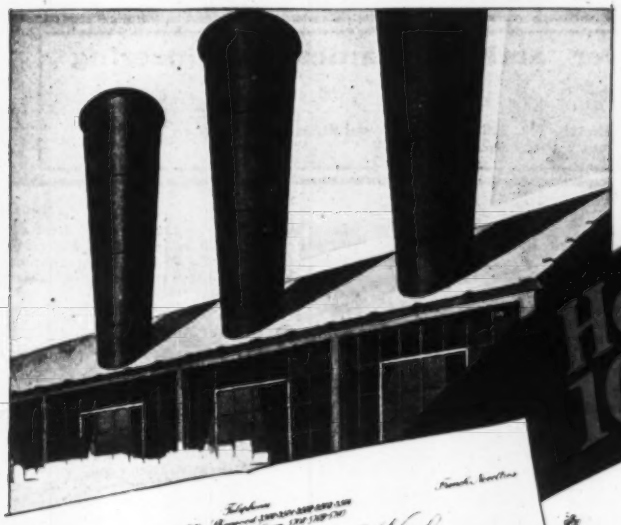
Mc Avoy Products Co. 463
19 W. Jackson Blvd., Chicago, Ill.
Will have at their exhibit, a Water Treatment, new in its discovery, that positively eliminates scale, corrosion, rust, pitting, foaming, etc., and that is drinkable. Non-poisonous, easily handling methods, and inexpensive.

Manistee Iron Works Co. 48
Manistee, Mich.
Exhibit will consist of several Pumping Units. There will be a sectional eight-stage Pump and a four-stage Boiler feeder for High Pressure service. There will be several Single stage Volute Pumps.

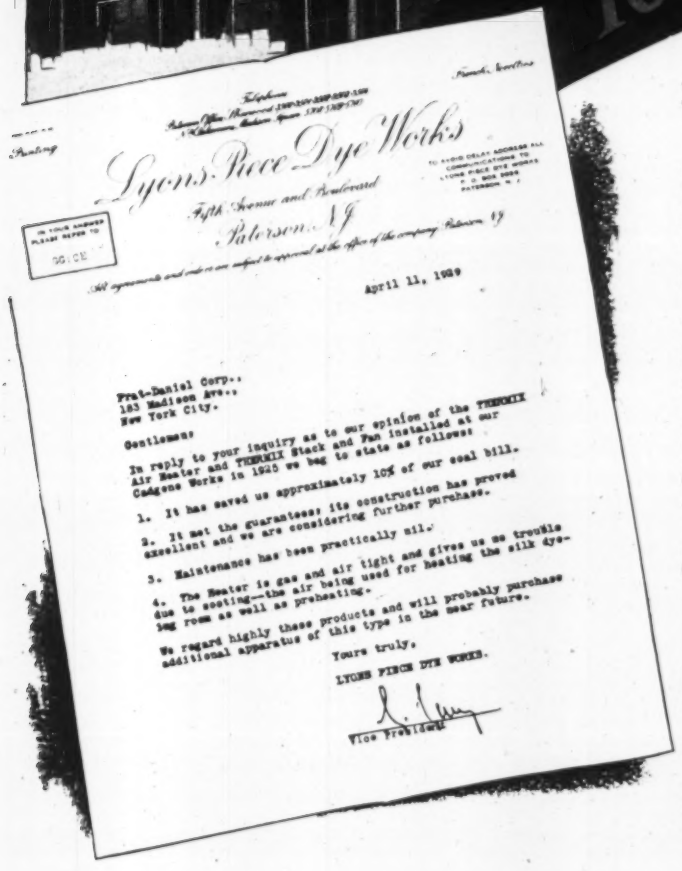
Manning, Maxwell & Moore (Inc.) 60
100 East 42nd St., New York, N. Y.

Manufacturers Record 40
Baltimore, Md.
A weekly business publication for 47 years "Devoted to the Upbuilding of the Nation Through the Development of the South"—making known the South's resources, and its industrial and agricultural advantages. It is the recognized authority on all matters relating to the South.

Continued on page 86



How They Save 10% of their Coal



Lyons Piece Dye Works
Fifth Avenue and Boulevard
Paterson, N.J.

April 11, 1929

Prat-Daniel Corp.,
183 Madison Ave.,
New York City.

Gentlemen:

In reply to your inquiry as to our opinion of the THERMIX Air Heater and THERMIX Stack and Fan installed at our Cadgene Works in 1925 we beg to state as follows:

1. It has saved us approximately 10% of our coal bill.
2. It met the guarantees; its construction has proved excellent and we are considering further purchase.
3. Maintenance has been practically nil.
4. The Heater is gas and air tight and gives us no trouble due to soot ing—the air being used for heating the silk dye-ing room as well as preheating.

We regard highly these products and will probably purchase additional apparatus of this type in the near future.

Yours truly,
LYONS PIECE DYE WORKS.
Vice President

Here's a letter from the Lyons Piece Dye Works in which they state that the Thermix Air Heater and the Thermix Stack have saved about 10% of their coal.

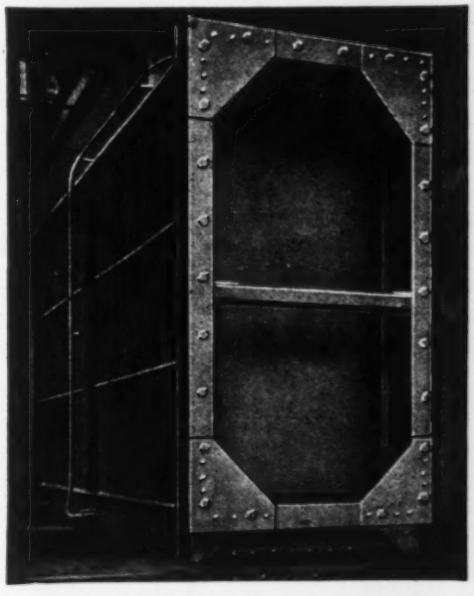
This installation is of particular interest because of the enviable reputation this concern enjoys for dyeing high-grade silks, many of them in exquisite pastel shades. Air from the Thermix, which is heated by waste flue gas, is used to heat their dyeing room in place of steam coils.

They further state, after four years of use, that the Thermix met all guarantees, that maintenance cost has been practically nil, and that the heater is gas and air tight.

You, too, could very materially reduce your coal bills with

THERMIX STACK and AIR HEATER

See our Exhibit at New York Power Show, Booths 26 and 26-A



The Thermix Air Heater utilizes outgoing *waste* gases to heat incoming fresh air. Thus, it furnishes clean heated air at *no cost* to dry textiles, paper, leather, fruit, etc.; to preheat air, to increase the efficiency of boilers; or to heat buildings.

Thermix Stack is an improved design of a combination fan and stack built as a unit and operating as a unit. It uses less power than ordinary induced-draft and costs much less because there is less material and labor in its production than for a fan, breeching and stack, or for a chimney.

Let us tell you more about these fuel savers. Mail the coupon, or write for catalogs mentioned in the coupon.

Prat-Daniel Corporation

183 Madison Ave. New York, N. Y.

The Babcock & Wilcox Co., New York, Exclusive Sales Representatives for Thermix Heaters to Preheat Air for Boilers.

Manufactured and sold in Canada by
Riley Engineering & Supply Co., Ltd., Toronto

Manufacturers of Thermix Air Heaters and Thermix Stacks

Prat-Daniel Corp.
183 Madison Ave., New York, N. Y.

Without obligation, please send the following:

- ☐ Catalog S-11 on Thermix Stacks
- ☐ Catalog T-11 on Thermix Air Heaters
- ☐ Catalog C-11 on Thermix Stacks for Cinder Removal

Name .....

Address .....

Town ..... State .....

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 347—Second Floor—*Diagram on Page 108*
Booths No. 400 to 569—Third Floor—*Diagram on Page 110*

Marburg Bros. (Inc.) ..... Booth 2 E, 298
90 West Street, New York, N. Y.
"Thiel" Die Filing and Sawing Machines are exhibited. In these machines the jig frame is solidly guided at its lower and also at its upper end. The work is first sawed out along the line and then filed to line of templet. Length of stroke as well as distance between upper and lower file and saw holder are adjustable making capacity of machine very flexible.

Mason Regulator Co. 223, 224
Dorchester Center, Boston, Mass.
This exhibit will include a complete line of Pressure Reducing Valves, Pump Governors, Damper Regulators and Balanced Valves. One of the features will be their No. 329 double diaphragm auxiliary operated reducing pressure valve used for holding the reduced pressure at a minimum variation.

Materials Handling & Distribution 445
420 Lexington Ave., New York, N. Y.
Will exhibit their publication, Materials Handling & Distribution.

Mayflower Oil Burner Corp'n 518, 519
5002 Hudson Blvd., West New York, N. J.
Manufacturers of Oil Burners.

Mechanical Catalog 80
29 West 39th St., New York, N. Y.
Published annually by the American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. The only specialized reference work for the buyer and specifier of mechanical equipment and engineering materials. Contains Mechanical Equipment Directory. Copies will be available for inspection.

Mechanical Engineering 80
29 West 39th St., New York, N. Y.
Published monthly by The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y. The only technical publication in America which covers all branches of mechanical engineering practice. Copies available for inspection.

Mercoid Corp'n 215, 216
564 W. Adams St., Chicago, Ill.
Showing Automatic Mercoid Electrical Controls used in connection with oil burners, forced draft coal burning equipment, unit heaters and refrigeration and in numerous industrial applications where temperature, pressure or vacuum control is desired. The main features will be oil burner Safety Control, Mercoid Combination Low Water Cutoff and Pressure Control, as well as Controls for close regulation of Steam pressures up to 200 lbs., and Temperatures up to 600° F.

Merrick Scale Mfg. Co. 237–240
188 Autumn St., Passaic, N. J.
Will have on exhibit the Merrick Conveyor Weightometer, which is a conveyor scale—the Merrick Addoweight weighting buckets of coal passing along a monorail track—the Merrick Mechanical Weighman for weighing tanks of material—the Merrick Acquitas, which is a printing platform scale.

Midwest Mfg. Co. (Inc.) 524, 525
City Bldg., Bradford, Pa.
Midwest products exhibited include: Midwest Air Filters, including automatic, standard unit, compressor and oil engine filters; Midwest humidifiers; Midwest continuous Steel Inserts. Special features of the exhibit will be Midwest automatic type HC air filter for continuous service, automatic type SH filter for intermittent service, and automatic type SV, small size air filter.

Midwest Piping & Supply Co. 221
1440 S. Second St., St. Louis, Mo.
Will exhibit "Globack" joints for 600, 900, and 1350 pounds pressure piping. Microphotographs of "Globack" joint lap sections will indicate the improved structure of the metal resulting from the method of hot working. Other Midwest contributions to the development of high pressure piping will also be shown.

Mill & Factory Illustrated 445
420 Lexington Ave. New York, N. Y.
Will exhibit their monthly publication, Mill and Factory Illustrated.

Millers Falls Co. 431
Millers Falls, Mass.
Displaying their full line of Portable Electric Drills, Grinders, Sander, Hammers and Screw Drivers.

Mine Safety Appliances Co. 268
Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.
Will exhibit a complete line of Safety Appliances for the power industries, including the new Edison Lineman's Lamp for night repair crews, the F-M Continuous Flammable Vapor Indicator, the new Jones Detector, The Burrell All Service Gas Mask, M-S-A Hose Masks, Portable H-H Inhalator, a resuscitation device, etc."

Minneapolis-Honeywell Regulator Co. 246
Minneapolis, Minn.
Products to be shown are: Industrial Motor Valves; Electric Motor Driven Self contained Speed Reducers; Electric Motor Automatic Shut-off Valves of both direct and reverse-acting types; Electric Motor driven Steam Radiator Valve; Small Magnet Operated Valves; Temperature Regulators comprising the bimetallic strip actuated types; Pressure Controllers applicable to the regulation of pressures between 02" of vacuum to a maximum of 150 lbs. pressure; Safety Combustion Controllers of both the radiant energy actuated diaphragm type and the bimetallic strip variety; and Pyroswitch.

Mixing Equipment Co. (Inc.) 279, 280
229 E. 38th St., New York, N. Y.
Will exhibit electrically driven self contained mixing units under the trade name of LIGHTNIN' PORTABLE MIXERS furnished in sizes from 1–20 to 10 H. P. of the screw propeller type; side angular propeller type for fixed installations on tanks of any size or shape.

Morrison Machine Co. 209, 210
1171–1225 Madison Ave., Paterson, N. J.
The products that will be exhibited are various sizes and models of Speed Reducing Transmissions, featuring a gear reduction unit with a glass outer casing which will be in operation to show the lubrication which is accomplished by means of a Patented Arrangement. Also featuring several right angle drive units.

Morse Chain Co. 263, 264
Ithaca, N. Y.
Display will include the Morse Silent Chain Drive, Morse Flexible Coupling, Morse Single, Double and Triple Reduction Speed Reducers, and both the Ring and Disc Oiling Devices. Products will be shown in action to illustrate actual operating conditions.

Moto Meter Gauge & Equip. Corp'n 622, 623
11 Wilbur Ave., Long Island City, N. Y.
Will exhibit Industrial Dial Thermometers, Pressure Gages, and Recorders.

Motor Tool Spec. Co. 612
14 East Jackson Blvd., Chicago, Ill.
Display will include Snap On Socket Wrenches, Ratchet Wrenches, Blue Point Engineer's Wrenches, Boxocket Wrenches; also Snap-On sockets and special shanks for use on electric and pneumatic motors. Will show Snap-On ratchet wrenches in action.

Murray, Thos. E. (Inc.) 64
88 Lexington Ave., New York, N. Y.
See Adv. Page 128
Will illustrate some Power Plants, Buildings and Industrial Plants recently designed and the advantages that may be secured by the adoption of modern methods of steam and power generation in industrial plants, and the advisability of securing the services of capable power plant specialists experienced in the work. Booth No. 64 will also be occupied by the Murray Radiator Corporation, who will show a complete line of Radiators and Chilling Units of the extended surface type, together with new designs and arrangements of enclosures. The new Electric Convection Radiator will be exhibited for the first time.

Murray Radiator Co. 64
88 Lexington Ave., New York, N. Y.
Will exhibit a complete line of Radiators and Chilling Units of the extended surface type, together with new designs and arrangements of enclosures. The new Electric Convection Radiator will be exhibited for the first time.

Nash Engineering Co. 53, 66
South Norwalk, Conn.
Manufacturers of Gas Compressors, Air Compressors, Vacuum Pumps, Condensation Pumps, Centrifugal Pumps, Sewage Ejectors, and Condensation Return Systems.

Nathan Mfg. Co. 530, 531
250 Park Ave., New York, N. Y.
Miscellaneous Mechanical Lubricators in connection with various types of bearings and other parts to be lubricated shown in actual operation. In all Nathan Mechanical Lubricators a simultaneously oscillating and reciprocating piston is provided for each feed. No valves are used.

National Ass'n of Power Engineers 23
417 S. Dearborn St., Chicago, Ill.

National Company (Inc.) 76
Jackson, Sherman and Abbott Sts., Malden, Mass.
Will exhibit Water Column Gauge Glass Illuminators, particularly the new "Type L" National Illuminator for flat type gauges, electric compartment cell door hardware.

National Engineer 23
890 Old Colony Bldg., Chicago, Ill.

National Lead Co. 258
111 Broadway, New York, N. Y.
Demonstration of the methods of installing Cinch Expansion Anchors, illustrating the merits of the device. Photos and motion displays showing typical installation jobs.

National Tube Co. 441–443
Frick Bldg., Pittsburgh, Pa.
Will exhibit NATIONAL Welded and Seamless Pipe for Bending and Flanging, and all types of Power Piping—NATIONAL Scale Free Pipe—NATIONAL Copper-Steel Pipe—NATIONAL Seamless Boiler Tubes.

Neckar Water Softener Corp'n 260
608 Fisher Bldg., Detroit, Mich.
Will feature a System of Boiler Feed Water Treatment based on recirculation and continuous blow down, and will have on display typical flowsheets and photographs of Neckar installations in this country, together with some of the special valves and fittings used with the process.

Neemes Foundry (Inc.) 56
Troy, N. Y.
Will exhibit full size operating models of the NEEMES AUTOMATIC STOKER, NEEMES SUPERIOR DUMPING GRATE and NEEMES IMPROVED SHAKING & DUMPING GRATE each of the models will be so erected to permit access to entire mechanism for examination and so arranged that it can be operated by the interested spectator.

New York & Richmond Gas Co. 7
Stapleton, Staten Island, New York, N. Y.
Exhibit will feature heat and coal for industry, being subdivided into exhibits showing complete lines of building heating and water heating equipment, and various industrial applications of gas for production purposes. Where practicable the units will be either in operation, or capable of operation.

Nicholson, W. H., & Co. 92, 93
138 Oregon St., Wilkes Barre, Pa.
Exhibiting Piston Operated Steam Trap, Weight Operated Steam Trap, All Metal Flexible Coupling, and Four-Way Valves and Steam Specialties.

Norma-Hoffmann Bearings Corp'n 312
Stamford, Conn.
See Adv. Pages 72, 129
Will exhibit a complete line of ball, roller and thrust bearings including several new types of bearings which have been recently introduced. These include ball bearings with special forms of dust protecting and grease retaining devices as well as our extra light series of ball and roller bearings having a very large bore with a small outside diameter. Also; various sectioned parts in which our bearings are applied, the sections being made in such a way as to demonstrate the principles of mounting involved.

Northern Equipment Co. 19
Erie, Pa.
Exhibiting the Copes Feed Water Regulator In both the standard design and the Type "R" for high pressures, the Copes Pump Governor, the Copes Condensate Control, the Copes Water Level Indicator, the Copes Valve Movement Indicator, and the Copes Control Valve.

Oakite Products (Inc.) 419, 420
42A Thames St., New York, N. Y.
Will feature their complete technical and engineering services that are valuable guides.

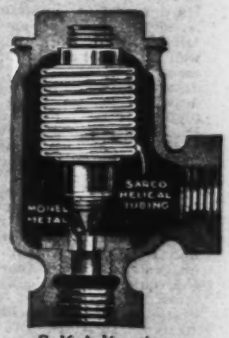
Continued on page 88

The boss says: "Since we installed Sarco Steam Traps we have used much less coal, resulting in a saving of hundreds of dollars. In addition, we saved about two-thirds of the money we expected to spend for traps."

The engineer says: "Sarco Traps made my job easier. I screwed them right into the pipe line without much work. If the boss had bought more of those old style bucket or float traps, I would have had to dig a lot of pits and build a bunch of platforms to install them. And the Sarco Traps never give any trouble or require any attention."

The fireman says: "I was about ready to throw up my job because I had to shovel so much coal that it was getting me. After they put in those Sarco Steam Traps it was easy to keep up steam with a whole lot less coal to shovel."

Sarco Steam Traps are self-adjusting for any steam pressure from 0 to 100 lbs. They have no floats, buckets or intricate parts to cause trouble.

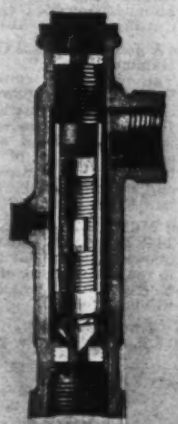


Self-Adjusting Type No. 9 Sarco Steam Trap

They are opened by condensation and closed by steam. Consequently they cannot freeze. Moreover, Sarco Steam Traps drain condensate as soon as it forms and return it to the hot well while still hot, so less coal is required to convert the condensation back into steam. Another important feature is that they cannot air bind.

FREE Trial

Let us send you a Sarco on 30 days' free trial. If not more than satisfied with it, you may return it and the trial won't cost you one cent. Write for Catalog E-95, or mail the convenient coupon.



Adjustable Type No. 7 Sarco Steam Trap

SARCO CO., Inc.

183 Madison Ave. New York City

Boston Chicago Detroit Pittsburgh
Buffalo Cleveland Philadelphia St. Louis
Sarco (Canada) Limited, 1605 Delorimier Ave., Montreal
Walker, Crosweller & Co., London, S. E. 1

SARCO STEAM TRAP

Sarco Co., Inc.,
183 Madison Ave., New York

☐ Send a Sarco Steam Trap on 30 days' free trial as follows: Size.....for pressure.....lbs.
☐ Send a copy of your Booklet E-95

Name.....

Address.....

Town.....State.....

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY of EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

to power plant users of cleaning material. The display will contain interesting comparisons of exchanger and condenser tubes and all other power plant equipment, before and after cleaning with Oakite.

Ohio Forge Co. 604
Cleveland, Ohio.

Okonite Co. 619
501 Fifth Ave., New York, N. Y.
Exhibit consists of samples of Okonite Rubber, Varnished Cambric, and Paper Insulated Super high-tension Power Cables, Friction and Rubber Insulating Tapes, Portable Cords and Flexible Power Cables.

Okonite Callender Cable Co. (Inc.) 619
Paterson, N. J.

Olsen, Tinius, Testing Machine Co. 17
500 N. 12th St., Philadelphia. Pa,
Will demonstrate their very latest production type "Cloudburst" Hardness Tester and Method of Superhardening Steel, which will be in operation. There will also be demonstrated the very latest Herbert Pendulum Hardness Test equipment, and the very latest Olsen Production Type Direct Motor Driven Brinell Hardness Test Equipment, as well as the latest Hardness Testing Equipment for testing rubber. There will also be demonstrated equipment for determining the drawing quality of sheet metal or strip steel, together with various sizes of Verifying or Proving Rings for both testing machines as well as for checking Brinell Hardness Testers. There will also be on exhibit the very latest Olsen Type of Extensometer and Strain Gages, as have been developed up to the present time. For balancing rotating parts, they will demonstrate their very latest development in the Olson-Lundgren Dynamic Type of Balancing Machine, operating on centrifugal high tension spark principle. For balancing statically, one of the very latest Olsen-Lundgren Automatic Weighing Static Balancing Machines will be demonstrated. In addition to this equipment will be demonstrated the Olsen-Lundgren Automatic Weighing Connecting Rod Weighing Scale for classifying connecting rods with respect to their center of gravity.

Oxweld Acetylene Co. 334
30 East 42nd St., New York, N. Y.
Manufacturers of Oxyacetylene Welding and Cutting Outfits. Also supplies.

Paige & Jones Chemical Co. 72
Hammond, Ind.
The exhibit will consist of a model of the Paige & Jones Upflow Zelolite Softener; a chemical feeder with samples of Paige & Jones Chemical Boiler Water Treatment; a working exhibit of a Paige & Jones Lime and Soda type of softener-chemical-feed featuring the Electro-Magnetic proportioner and meter control. Sample of new coagulant Ferric-Alumina.

Paper Mill 421
1440 Broadway, New York, N. Y.
Showing data about the power consumption in the manufacture of pulp and paper on the North American Continent. Publications will be on display.

Paper Trade Journal 521
10 E. 39th St., New York, N. Y.

Parker Appliance Co 655, 656
10320 Berea Rd., Cleveland, Ohio
See Adv. Page 79
Will exhibit a complete line of PARKER TUBE COUPLINGS, Valves, Tube Benders, Flaring Tools and similar products. The line includes Fittings in brass, steel, monel metal, aluminum alloy and other industrial requirements. Various power plant plumbing assemblies, such as flow meter hookups, condensation test coils, draft meter valve manifolds, water column blowdown lines and similar power plant units, will be assembled at this display. PARKER products have gained great favor in the power plant as well as in the railroad industry and similar fields, where severe service requires a superior joint. Power plant engineers will find this exhibit interesting, as nearly every large power plant has PARKER TUBE COUPLINGS for instrument and similar small piping. PARKER Copper Plumbing is standard for the principal instrument manufacturers, such as Bailey Meter Company, Brown Instrument Company and others.

Booth

Peabody Engineering Corp'n 46
110 East 42nd St., New York, N. Y.
See Adv. Page 112
Will exhibit for the first time a recently developed, high capacity, combined Gas and Oil Burner that is designed along the same lines as their standard combined gas and oil burner. These burners are built to fire from 1000 lbs. of oil per hour to approximately 3500 lbs. of oil per hour or the equivalent gas and are installed either in the top of fire vertically downward or in the floor to fire vertically upward, the latter arrangements now being the more popular. The three-fuel burner, as it is called, is designed to burn either oil, gas or pulverized coal, separately or in combination with the same degree of ease and efficiency as either of the fuels can be burned with a burner. The three-fuel burner is being exhibited this year, due to the increasing interest shown in those parts of the country where the price differential between oil, gas and coal is subject to fluctuation so that it is not possible to predict which of the three will be the most economical fuel to burn a year hence.

Peerless Electric Co. 483, 484
740 West Market St., Warren, Ohio
Exhibiting Electric Motors of standard and special designs, Exhaust Fans, Window Ventilators, Furnace Fans and a line for spring delivery of Desk Fans in colors.

Peerless Machine Co. 529
1218 Sixteenth St., Racine, Wisc.
Will exhibit their Universal Type High Speed Metal Sawing Machines in both 6" × 6" and 9" × 9" sizes together with their Universal No. 2 Portable Pipe Threading and Cutting Machine.

Pels, Henry, & Co. (Inc.) 2
90 West St., New York, N. Y.
Exhibiting quadruple combination punch, plate shear, angle, bar and tee cutter and coper, in two sizes. Also angle bar and tee shear with diagonal slide. Also high throat punching machine for beams and columns.

Pepins No-Jar Clutch Co. 641
67 Third Ave., Lowell, Mass.
Exhibiting the Pepin No-Jar Clutch. Exhibit will show four clutches, one installed with a motor.

Permutit Company 348, 444
440—4th Ave., New York, N. Y.
See Adv. Page 97
The principal and most interesting exhibit in Booth No. 348, will be a model of Water Softening and Filtering equipment such as is used in industrial plants. This model is about 4 feet long and is made exactly to scale after the design of a large commercial unit that delivers 100,000 gallons per day. Also showing in Booth No. 444, Ranarex instruments for recording CO_2 Gas Density, Ammonia Gas, etc.

Philadelphia Gear Works 13
Richmond and Tioga Sts., Philadelphia, Pa.
See Adv. Page 83
Will display Worm Gear, Spur Gear and Continuous Tooth Herringbone Speed Reduction Units, together with standard types of Gears.

Pipe-Saver Corp'n of America 446
Carthage, New York.
Will exhibit PIPE-SAVERS, metal sleeves for the protection of threaded pipe end, guaranteed to double the life of threaded pipe. Service men at the booth will give practical demonstrations showing how the device protects piping.

Pitts & Kitts Mfg. & Supply Co. 275
91 Seventh Ave., New York, N. Y.
Showing the following products: PERO PLAS, the plastic fire brick; PLASTIKOTE, the boiler wall covering; REDUCING VALVES; TRAPS: Full line of FLOAT and BALANCE VALVES; TEMPERATURE REGULATORS for liquids and etc.; THERMOSTATIC CONTROL for rooms; and HILL PUMP VALVE.

Pittsburgh Coal Co. 319
Pittsburgh, Pa.
Will exhibit Pennsylvania Coals for steam process and gas uses, prepared by special cleaning plants for regulating continuous grade and quality.

Booth

Pittsburgh Piping & Equipment Co. 434
35th and Charlotte Sts., Pittsburgh, Pa.
Will show various items of High Pressure Fabricated Piping material and will feature the "Pittsburgh Piping Creased Bend."

Plibrico Jointless Fire Brick Co. 92
1840 Kingsbury St., Chicago, Ill.
Exhibiting a model installation of Plibrico Jointless Furnace Lining. The Plibrico Flexo-anchor which prevents bulging, yet allows free movement with expansion and contraction. A model Plibrico Water Wall Installation.

Powell, Wm., Co. 344, 345
2521-31 Spring Grove Ave., Cincinnati, Ohio
Will display: A complete line of Bronze, Iron and Steel Globe, Angle, Check, Gate and Safety Valves; also Oilers, Lubricators, Grease Cups, and sundry engineering appliances. The display will be of an educational nature.

Power 42
10th Ave. and 36th St., New York, N. Y.

Power Age 609
95 King St., E. Toronto, Ont.
Exhibiting POWER AGE and FISHERS' MACHINERY GUIDE, serving the steam and electric power and machine tool and industrial fields, respectively, in Canada.

Power Engrg. & Fin. Pub. Corp'n, B Main Floor
551 Fifth Ave., New York, N. Y.

Power House 628
153 University Ave., Toronto, Ontario
Power House will exhibit copies of its regular issues, statistics regarding its circulation and class of readers and will also have on display the Power House Survey, giving thorough illustrations and charts information which advertisers and prospective advertisers will care to have.

Power Plant Engineering 37
53 W. Jackson Blvd., Chicago, Ill.
Booth will contain sample copies of our November 15th and December 1st issues. These may be had without charge.

Prat-Daniel Corp'n 26, 26A
183 Madison Ave., New York, N. Y
See Adv. Page 85
Will show their entire line of THERMIX products including the THERMIX plate type air heaters, THERMIX stream-line stacks and THERMIX cinder eliminating fans and stack. The main features of the exhibit will be their Type IV cinder eliminating and dust collecting fan in operation, representative THERMIX stacks of different types covering all ranges of operating conditions, as well as exhibits showing the detailed construction of our apparatus. The new features and improvements to be shown include the latest type of cinder eliminating and dust collecting fans, together with our improved type of fan and rotor of special design for high drafts and with special provision to minimize wear and insure a long life.

Pratt & Whitney Co. 631
Hartford, Conn.
Display will include No. 1-A Jig Borer complete with attachments and tool cabinet for holding all tools, as well as a feature display of Hoke Precision Gages together with thread and cylindrical gages of the various styles. Will also display the iron plates known as "Eight Pieces of Iron."

Preferred Utilities Co. (Inc.) 303-305
33 W. 60th St., New York, N. Y.
Booth No. 303 will be used for the exhibition of the Hart Oil Burner. Booths 304 and 305 will be used for the display of the Ray Fuel Oil Burner in all its types.

Pyrometer Instrument Co. 202
50 Howard St., New York, N. Y.
Exhibiting OPTICAL, RADIATION, INSERTION and SURFACE PYROMETERS, ULTA METERS.

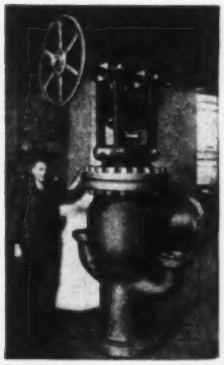
Quigley Furnace Specialties Co. 89
56 W. 45th St., New York, N. Y.
Will feature HYTEMPITE, the Quigley Refractory Gun, Quigley Acid-Proof Cement, and will demonstrate by a mechanical exhibit the resistance of Triple-A Protective Coatings to acids, alkalies, moisture, grease, oils, etc.

Continued on page 90

HEAVY DUTY STEAM VALVES
are built for pressures up to 1350 lbs.

The three valves pictured above are S&K Off-set Body Turbine Throttle Valves built for a steam station operating at 1200 lbs. pressure.

The S&K Valve line includes stop, check, non-return, triple-duty, throttle, bleeder line, reducing, gate and atmospheric relief valves. An interesting bulletin for each type.



16″ Toggle Top Non Return Valve

Call on us at the Power Show Booth 616

SCHUTTE KOERTING

1166 Thompson St.
PHILADELPHIA, PA.

Valve Specialists for Over Thirty Years

20″ Inverted Offset Body Throttle Valve

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Rawlplug Co. (Inc.) ..... Booth 539
66 West Broadway, New York, N. Y.
Exhibiting Rawlplug which are screw anchors made of jute fibre requiring a hole scarcely larger than the screw itself. When the screw enters the Rawlplug it is tightly compressed against the sides of the hole for the full length of the thread and not just at one point. The holding power of the Rawlplug is equal to or exceeds that of the present day anchoring devices.

Ray Burner Co. 303
170 Sutter Ave., San Francisco, Cal.
Manufacturers of Rotary Oil Burners.

Reading Steel Casting Co. (Inc.) 634, 635
Bridgeport, Conn.
Will exhibit a motor operated Gate Valve, a complete line of all series Steel Gate Valves and a complete line of Bronze Valves. Will have an interesting metallurgical display.

Realty Paint Sales Co. 464, 465
205 East 42nd St., New York, N. Y.
Exhibit will consist of miniature buildings characteristic of users of their products.

Reeves Pulley Co. 34, 35
Columbus, Ind.
The feature will be new designs of REEVES Variable Speed Transmissions which have been developed for many different types of requirements for variable speed control. These will include the automatic electrical control, the electrical remote control, the vertical design transmission equipped with motor base, and several other special units.

Reeves Pulley Co. of New York 34, 35
76 Dey St., New York, N. Y.

Refractory & Engineering Corp'n 25–25A
280 Madison Ave., New York, N. Y.
Manufacturers of Refractory Cements.

Reliance Elect. & Engrg. Co. 542, 543
1088 Ivanhoe Rd., Cleveland, O.
Products shown are: (1) 1 h.p., 900 r.p.m., A.C. motor (2) 25 h.p., 900 r.p.m., A.C. squirrel cage motor. (3) 5 h.p. 1740 r.p.m., fully-enclosed fan-cooled motor. (4) 15 h.p., 1150 r.p.m., Reliance D.C. heavy-duty motor (5) 20 h.p., D.C. motor-provided with semi-enclosing and fully-enclosing covers. (6) 3½ k.w., A.C.-D.C. Motor-generator set mounted on new type welded base.

Reliance Gauge Column Co. 81, 82
Cleveland, Ohio.
Manufacturers of Cocks, Gage; Floats, Nickel; Gage; Water; Water Columns.

Renold, Hans (Inc.) 326
200 Hudson St., New York, N. Y.
Manufacturers of Power Transmission Chains and Sprockets.

Richardson Scale Co. 14B, 15B
Clifton, N. J.
Will display a full size unit of a Richardson Apron Feed Automatic Crushed Coal Scale which is an automatic scale of the hopper type fed by means of an endless apron feeder built in as an integral part of the machine. Will also display a full size Richardson CONVEY-o-WEIGH.

Riley Stoker Corp'n 78, 79
Worcester, Mass.
Will exhibit one of their up-to-date No. 4 pulverizers, together with a No. 4 Riley Flare Type Burner. Also will exhibit a section of Riley-La Mont Water Wall. Also showing complete Jones Stoker including the Riflex Stoker Drive Unit.

Robins Conveying Belt Co. 514
15 Park Row, New York, N. Y.
Will exhibit a working model of the Robins Gyrex Screen, as well as several of our Timken Roller Bearing Equipped Troughing Idlers for Belt Conveyors including our new demountable type.

Roller-Smith Co. 603
233 Broadway, New York, N. Y.
Will exhibit their switchboard and portable type electrical measuring instruments, indicating and graphic styles, A.C. and D.C. in various case designs. Will show relays of different types. Also will exhibit representative types of air and oil circuit breakers. Will have electrically operated air and oil circuit breakers mounted on panels with instruments and other accessories which will show operating characteristics.

Rome Brass Radiator Corp'n 447-449
1 East 42nd St., New York, N. Y.
Will show Robras Radiators of various types, Roblast encased units for fan work, and their new Aulbras water heaters.

Roth Bros. & Co. 627
1400 West Adams St., Chicago, Ill.
Manufacturers of Electric Motors and Generators.

Roto Company 11
Sussex Ave. and Newark St., Newark, N. J.
Manufacturers of Mechanical Tube Cleaning Equipment for boilers, condensers, economizers, evaporators, etc. Also Hand Hole Seat Scrapers and Cap Cleaning Machines.

Rotor Air Tool Co. 653
5905 Carnegie Ave., Cleveland, Ohio
Exhibiting a complete line of portable Pneumatic Grinders, Buffers, Sanders and Drills, including the new Die Grinder and D-O Grinder, also the E-O, E-1-C, E-2C, E-4C and E-40-C Drills, ranging in drilling capacity from ⅛" to 1", and attachments and accessories.

Ruggles-Coles Engrg. Co. 30
120 Broadway, New York, N. Y.
(See Hardinge Co.)

Ryerson, Jos. T., & Sons (Inc.) 433
P. O. Box 484, Jersey City, N. J.
Will have on exhibition a general line of iron and steel commodities including Safety Treads, Grating, Babbitt Metal, Small Tools, Machinery, Boiler Fittings, Reinforcing Material, Stainless Iron Sheets, Tool and Alloy Steel, Special Sheets, etc.

Sarco Co. (Inc.) 33
183 Madison Ave., New York, N. Y.
See Adv. Page 87
Will show various types of Steam Traps for the industrial field, standard and special Temperature Regulators for hot water service tanks, industrial processing, dry kilns, etc. Will also show a line of regulators for refrigeration work, suitable for temperatures from 0 up. A special feature will be the complete Sarco heating line, including Inlet Valves, Thermostatic Traps, Blast Traps, Air Eliminators, and other apparatus required for low pressure vacuum and vapor heating systems.

Sauerman Bros. (Inc.) 564–569
470 S. Clinton St., Chicago, Ill.
Exhibit consists of a model equipment showing a typical coal storage layout which show the Sauerman Crescent Power Scraper stocking out and reclaiming coal. Will also show a new model equipment stocking out and reclaiming sand, gravel and stone. Both of the model equipments will show the Sauerman Crescent Scraper, Electric Hoists, Operating Cables and Blocks which are an exact duplicate of the latest Sauerman Durolite blocks.

Savage, W. J., Co. 654
Knoxville, Tenn.
Will exhibit and operate their line of Gray Metal Cutters which is an essential machine tool to any shop cutting sheet metal shapes. Also will exhibit samples of the work done by these machines in various lines of industry.

Sayre & Fisher Brick Co. 489
Sayreville, N. J.
Will exhibit three of their "SAFISCO" products; namely, "Safisco" Fire Brick Cement, "Safisco" Ground Fire Brick, and "Safisco" Fire Brick Shapes.

Schade Valve Mfg. Co. 76
2527 No. Bodine St., Philadelphia, Pa.
Will exhibit Steam, Water, Air and Oil Specialties; Pressure Reducing Valves, Regulators, Altitude Valves, Relief Valves, and Pressure Controls.

Schaefer, Frank H., Co. 413
Philadelphia, Pa.
Exhibiting By-Pass Valves.

Schutte & Koerting Co 616
1166 Thompson St., Philadelphia, Pa.
See Adv. Page 89
Exhibit will include Toggle Top Stop Check Valve built for 2000-lbs., working pressure, Gear Pumps for fuel and lubricating oils, Trip Throttle Valve for turbines, steam jet and water Jet Primers for pumps, Oil Cooler, Oil Burners, Boiler Feed Injectors and other Power Plant Equipment.

Schweiger Furnace Corp'n 211
50 Church St., New York, N. Y.
Manufacturers of Boiler Furnaces.

Scovill Mfg. Co. 69
Waterbury, Conn.
Will exhibit Scovill Cup Drawn Admiralty Condenser Tubing and will feature a new method for securing the condenser tubing into the tube sheet without the use of packing or ferrules. Will also exhibit brass, bronze, and nickel silver sheet, rod, wire, and tubing and a display of cap and machine screws in brass and steel.

Scully-Jones & Co. 263
2012 West 13th St., Chicago, Ill.
Exhibiting Production Tools, for Drilling, Tapping, Milling, Reaming, Counterboring and Spot Facing Operations, featuring the "SCULLY-JONES" principle of "Drive by the Square" and "Center by the Shank."

Sharples Specialty Co. 45
23rd and Westmoreland Sts., Philadelphia, Pa.
Will exhibit a Presurtite, or totally-enclosed Super Centrifuge, a Laboratory model, a cross-section machine, and also a new type Centrifuge, known as the 20" Horizontal Centrifuge, designed to load and unload while operating at full speed.

Shays, J. R., Jr. (Inc.) 422
100 Greenwich St., New York, N. Y.
Will show samples of Photographs of Machinery, Boiler Plants, Engineering equipment, as well as enlargements of same. Will feature our "Lo-Cost" photographic prints which are 8 × 10 photographs printed on a special paper by photographic process.

Shepard Niles Crane & Hoist Corp'n 230, 231
370 Schuyler Ave., Montour Falls, N. Y.
Will exhibit two of their new compact Hoists in operation and also have an educational display of enlargements from photographs showing installation and portrait views of their equipment.

Signal Engineering & Mfg. Co. 547
154 W. 14th St., New York, N. Y.
The exhibit consists of Magnetic Relays for all applications requiring less than 20 ampere-contact capacity; electrically operated audible signals of all types; a complete SIGNAL CALL code calling system, specially suitable for industrial plants, and complete interior FIRE ALARM SYSTEM.

Silent Hoist Winch & Crane Co. 548, 549
762 Henry St., Brooklyn, N. Y.
Will exhibit SILENT HOIST motor truck Winches and Cranes; Telescopic Ash Hoists, hand and electric; Electric Capstans, Winches, Car Pullers and Barge Movers; Cargo Winches, Dock Winches and Boat Hoists, Worm Gear Speed Reducers.

Simplex Valve & Meter Co 76
6753 Upland St., Philadelphia, Pa.
See Adv. Page 91
Will exhibit Simplex Boiler Feed and Condensate Meters of the Indicating, Recording and Totalizing Type for use with Simplex Venturi Tubes.

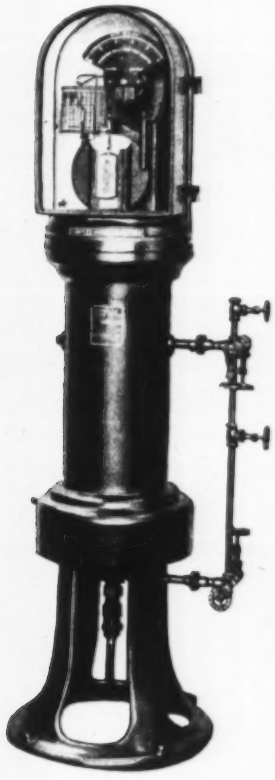
Smidth, F. L., & Co 318
225 Broadway, New York, N. Y.
See Adv. Page 111
The Lenix Short Center Belt Drive will be exhibited. Special attention will be given to the silent operation of a fine piece of machinery. The short pulley centers not only possible, but preferable, with the Lenix, will be featured. High belt speed with safety, automatic adjustment of belt tension to meet varying loads will also be demonstrated.

Smith, David H., & Son 283, 284
5111 Second Ave., Brooklyn, N. Y.
Manufacturers of Machine Tools.

Smith-Monroe Co. 272
1912 South Main St., South Bend, Ind.
Featuring Gast Compressed Air Separators and Gast Compressed Air Aftercoolers. The Gast Air Separators will be shown in operation. Water will be admitted with the air to demonstrate that separator will remove every trace of moisture in the air.

Continued on page 92

SIMPLEX METERS
dovetail into the high-pressure program



Along with the development of steam generating apparatus that work under pressures of between 1000 and 2000 pounds, Simplex meters have advanced step by step. This has been made possible by the selection of materials such as Seamless Steel Tubing and Steel Forgings.

Simplex Venturi Tube Meters are speedy and accurate in recording variations in rate of feeding. The uniformly graduated flow dial permits the operator to read low flows accurately like the higher ones.

— See one —
Booth 76E Power Show, New York

SIMPLEX VALVE and METER CO.
6753 Upland Street, Philadelphia

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* Booths No. 200 to 348—Second Floor—*Diagram on Page 108*
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

Smith & Serrell 85, 86
28 Washington Place, Newark, N. J.
See Adv. Page 124

In addition to showing entire couplings and sectional models of FRANCKE couplings that are now protecting more than 85,000 drives from misalignment troubles, load shocks and vibrations, will have several typical installations where FRANCKE couplings are used.

Snap-On Wrench Co. 612
14 E. Jackson Blvd., Chicago, Ill.
Display will include Snap-On Socket Wrenches, Ratchet Wrenches, Blue Point Engineer's Wrenches, Boxocket Wrenches; also Snap-On sockets and special shanks for use on electric and pneumatic motors. Will show Snap-On ratchet wrenches in action.

Snyder, Fred 407
Maspeth, N. Y.

Sommer, Franz 407
Hof-Saale, Germany

South Bend Lathe Works 459
426 E. Madison St., South Bend, Ind.
Will exhibit four New Model production and tool room Screw-cutting Precision Engine Lathes, with countershaft and motor drives, bench and floor legs, and standard and quick-change gears.

Southern Power Journal 10
Grant Bldg., Atlanta, Ga.

Sowdon, W. K., Co. (Inc.) 76
342 Madison Ave., New York, N. Y.
Representing: National Company (Inc.), Schade Valve Mfg. Co., Ernst & Co.

Spencer Turbine Co. 452, 453
499 New Park Ave., Hartford, Conn.
Will exhibit the stationary vacuum cleaner or, as it is sometimes called, the pneumatic sweeping equipment. Will also exhibit one of their slow speed multi-stage vacuum cleaner machines with separator, and a complete line of hose and cleaning implements for various applications. In addition, a ten Horsepower Spencer Turbo-Compressor.

Square D Co. 613, 614
6060 Rivard St., Detroit, Mich.
Will exhibit Power Panels, Lighting Panels, Safety Switches; Industrial Controller Apparatus-Motor Starters; SQUARE-Duct System, Voltage Testers, Etc.

Standard Oil Co. of N. Y. 207–209
230 Park Ave., New York, N. Y.
Exhibit will consist of an attractive display of the uses of Petroleum Products in the industries. Fuel Oils, Automotive Oils and Industrial Lubricants will be featured. Information relative to new developments will be available.

Star Expansion Bolt Co. 302
141 Cedar St., New York, N. Y.
Will exhibit a complete line of expansion bolt products and drilling devices for making attachments to masonry.

Starrett, L. S., Co. 456
Athol, Mass.
Will exhibit a complete line of Fine Mechanical Tools, such as Micrometers, Indicators, Gages and other Measuring Instruments, together with their complete line of Tungsten and High Speed Steel Hack Saw Blades.

Steacy, Schmidt Mfg. Co. 30
York, Pa.

Sterling Engine Co. 50
1270 Niagara St., Buffalo, N. Y.
Will exhibit three engines including one of their large Viking "2", 8 cylinder engines, probably the largest bore 8 cylinder gasoline engine and most powerful employed for stationary duty. The Sterling Dolphin 8 cylinder engine has long been a most successful engine and is used for a variety of duties.

Stevens Walden-Worcester (Inc.) 642
475 Shrewsbury St., Worcester, Mass.
Manufacturers of Wrenches

Stockham Pipe & Fittings Co. 556, 557
Birmingham, Ala.
Will feature their new Stockham Fantz-Type Return Bend and a complete line of Stockham Fittings. No rolled-in tubes, stream line flow and simplicity are the cardinal points of the Stockham Fantz-Type Return Bend design.

Booth

Strong, Carlisle & Hammond Co. 413
Cleveland, Ohio
In addition to their general line of Steam Specialties, which include, steam and gasoline traps, vacuum and listing trap, strainers, non-return valves and engine stops; will exhibit recently perfected forged steel steam traps and globe valves for high pressures and temperatures.

Sturtevant Mill Co. 44A
(Harrison Square) Boston, Mass.
Will exhibit an Automatic Coal Crusher and Sampler for preparing coal samples. A Whirlwind Centrifugal Selector, a machine for dry classifying and separating materials between 60 mesh and 350 mesh, also exhibit of materials handled and the work done on them by various Sturtevant machines.

Sumet Corporation 510
1543 Fillmore Ave., Buffalo, N. Y.
Will exhibit a small mechanical display in operation, showing Sumet Bearings in actual running operation in three different manners. First, bearings running in water. Second, bearings in steam. Third, bearings running dry under a heat of about 550 degrees F. Will also have a display of numerous sizes and shapes in castings, together with our processed drawn rod.

Sundh Electric Co. (Inc.) 435, 436
Parkhurst at Ave. C, Newark, N. J.
The exhibit will consist of representative standard apparatus and will include types of control particularly adapted for use in New York City. In addition the Bulletin 6013 Aclinestor a new AC full voltage automatic starter will be shown.

Superior Die Casting Co. 606
875 E. 70th St., Cleveland, Ohio
Exhibit will constitute a wide range of Die Castings made of Super Cast Alloys of Zinc, tin, lead and aluminum bases. In addition to the broad display of intricate and varied castings, they will show the development which obtains along the metallurgical lines of Super Cast Alloys.

Suter, Alfred 479
200 Fifth Ave., New York, N. Y.
Exhibiting Material Testing Machines of the Losenhausenwerk A. G. in Duesseldorf, Germany. Some new devices will be shown as Lathe and Drill Tool Testing Table, Hand Ball Tester and our new Wire Tensile Tester.

Swartwout Co. 75
18537 Euclid Ave., Cleveland, Ohio
Will exhibit their complete line of Steam Specialties for Power Plants. The special feature will be a working exhibit of their latest type of feed water regulator in combination with their Type "SLP" variable excess pressure regulator.

Sweet & Doyle Fdry. & Mch. Co. 227, 228
Green Island, Troy, New York
Will have on display a complete line of S & D Conversion Burners, including an operating display consisting of an S & D Burner in a coal boiler.

Tagliabue, C. J., Mfg. Co. 59
18–88 Thirty-Third St., Brooklyn, N. Y.
Featuring TAG Recording, Indicating and Controlling Instruments in the new round form case construction. A new model of the TAG Automatic Steam-Operated Controller; the new TAG Automatic Recorder-Controller. Other instruments exhibited are TAG Industrial Thermometers and Recording Pressure Gages, Barometers, Absolute Pressure Gages, U-Gages, etc. Testing Instruments for conducting all of the A.S.T.M. tests on lubricants and on fuel oils. Etched Steam Thermometers, Hydrometers, Hygrometers, etc.

Tallmadge, Webster & Co. (Inc.) 416
50 Church St., New York, N. Y.
Manufacturers of Electric Heat Controls and Heating Apparatus.

Taylor Instrument Cos. 601
Rochester, N. Y.
Will exhibit a complete line of Indicating and Recording Thermometers, Index (dial type Thermometers), Thermo-electric Pyrometers of the indicating and recording type, Mercury Column Vacuum Gauges, Barometers, Glass Engraved Stem Thermometers for testing, automatic temperature regulators, etc.

Templeton, Kenly & Co. 288–290
1020 S. Central Ave., Chicago, Ill.
Exhibiting Simplex Jacks.

Booth

Texas Co 460, 461
17 Battery Place, New York, N. Y.
See Adv. Page 127

Will exhibit Lubricating Oil and Grease for use on power generating and transmission units with special reference to conservation of power or limiting power losses due to friction, through scientific selection of lubricants with reference to the work factor involved. The Texas Company has done considerable research work, based on the power saving factor of lubrication and has developed a number of new products during the past year for certain types of work and will produce others as their research work progresses.

Thomas Grate Bar Co. 276
Drawer 1111, Birmingham, Ala.
Products to be shown:—Complete working models as well as full size castings covering the Thomas WSD (Wiggling-Shaking-Dumping) Grate equipment for burning coal, coke, small Anthracite, and mixtures of these fuels with refuse material, also Thomas ELLIPTIC and Durable Stationary Grates.

Tide Water Oil Sales Corp'n 15A
11 Broadway, New York, N. Y.
Showing a complete line of petroleum products designed to meet the most exacting requirements of industrial and power equipment. Also featuring a Display of Tycol industrial lubricants and motion picture of plant lubrication.

Time-O-Stat Controls Co. 306, 307
Elkhart, Ind.
Manufacturers of Thermostatically and Electrically operated Valves, Electric Thermostats, Electric Switches, Electric Operated Regulators, Temperature Regulators and Electric Mercury Switches.

Timken Roller Bearing Co. 332, 333
Canton, Ohio
Exhibit will consist of an assortment of Tapered Roller Bearings suitable for use in different various sorts of power plant equipment.

Toledo Pipe Threading Mach. Co. 411, 412
1425 Summit St., Toledo, Ohio
Exhibit will be their complete line of Pipe Threading and Cutting Tools from ⅛" to 12", also small Portable Pipe Machines, Power Drives, Work Benches and Vises.

Topping Bros. 288–290
159 Varick St., New York, N. Y.
Representing: Bearium Bearings (Inc.), Black & Decker Mfg. Co., Templeton, Kenly & Co., and Torchweld Equipment Co.

Torchweld Equipment Co. 289
224 N. Carpenter St., Chicago, Ill.
Exhibiting Gas Welding and Cutting Equipment.

Trane Co. 252, 253
Second and Cameron Aves., La Crosse, Wisc.
Featuring a double arch with Concealed Heater installation showing cut-away construction and also a completed installation. Unit Heaters, the other major feature of the exhibit. Will be supplemented with their Specialties and Pump lines.

Trerice, H. O., Co. 267
1338 W. Lafayette Blvd., Detroit, Mich.
The Trerice Steam Trap has some very distinctive features. The trap is constructed with a bucket on the bottom of which is a propeller which rotates the valve at each discharge. This insures the valve seating in a different place at each discharge and eliminates the possibility, to a large extent, of wire drawing.

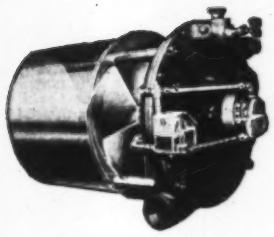
Tri-Lock Co. 433
5555 Butler St., Pittsburgh, Pa.
Manufacturers of ventilated steel flooring and safety steps, steel armor-units for concrete floors and stairways.

Troy Engine & Machine Co 555
Troy, Penna.
See Adv. Page 95

Exhibit will be a small vertical steam engine turning over, and having a glass insert in one side with the interior of the engine illuminated so that the lubrication system is easily observed. This is an interesting demonstration of what the modern self-oiling engine accomplished.

Continued on page 94

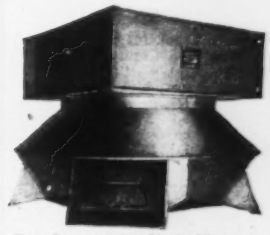
L. J. Wing Mfg. Co.



Wing Turbine Blower

Forced Draft Blowers

for Pressure or Heating Boilers



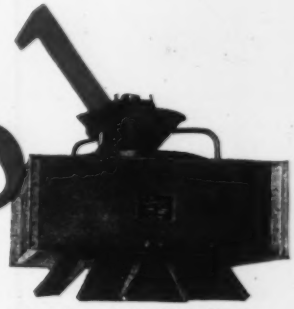
Featherweight Unit Heater Type LC

Featherweight Unit Heaters

Motor Driven Blower

Wing-Scruplex Fans and Exhausters

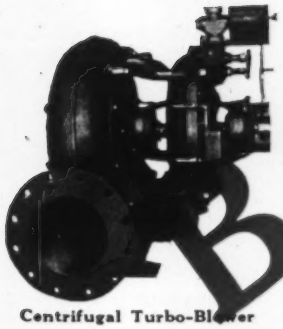
for Ventilating



Featherweight Unit Heater Type HC

Centrifugal Turbo-Blowers

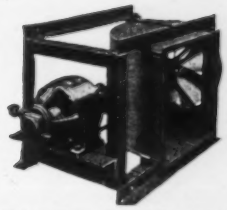
for Gas Producers, etc.



Centrifugal Turbo-Blower

Steam Turbines

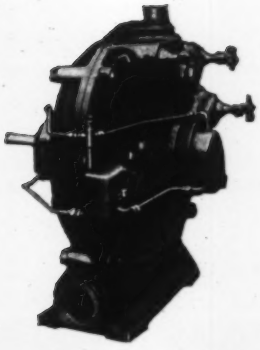
Capacities up to 50 H.P.



Wing-Scruplex Exhauster

The services of our engineers are at your disposal—either at our booth or at your own offices.

Booth 61—Middle Aisle—Main Floor



Wing Steam Turbine

L. J. Wing Mfg. Co.
156 WEST 14TH ST. NEW YORK, N.Y.

Wing-Scruplex Fan

BOOTH 61

Eighth National Exposition of Power and Mechanical Engineering

DIRECTORY *of* EXHIBITORS

Booths No. 1 to 95—Main Floor—*Diagram on Page 106* **Booths No. 200 to 348—Second Floor—*Diagram on Page 108***
Booths No. 400 to 656—Third Floor—*Diagram on Page 110*

Booth

Trumbull Elect. Mfg. Co. **3M**
Plainville, Conn.
The display will consist of one large display board on which is mounted general purpose Safety Switches, Magnetic and Manually Operated Motor Starting Switches and Panelboards. This will be supplemented by a special Magnetic Switch display board which will show the switch connected to a 3 H.P. 220 V. 3 Phase Motor.

Tube-Turns (Inc.) **405, 406**
1256 Logan Ave., Louisville, Ky.
Will exhibit their product, the Tube-Turn a seamless drawn fitting for pipe welding. The exhibit will demonstrate by model installations, photographs and the product itself the application of Tube-Turns to all kinds of piping. The exhibit also will show the range of sizes in which Tube-Turns are made.

Unishear Co. (Inc) **645, 646**
270 Lafayette St., New York, N. Y.
Exhibiting complete line of Unishears, flat stock cutting machines; Mighty Midget Unishear-Small portable motor driven tool 6½ pounds; Models A-14 and A-10—Bench type, capacity 14 gauge and 10 gauge respectively; and Model O built on same principle with various frames adapted for inside cutting.

Universal Gear Corporation **617, 618**
327 S. LaSalle St., Chicago, Ill.
Will exhibit the Heliocentric Speed Reducers in reductions from ten to one, to twelve thousand to one; as separate units and, also, built into the end frame of standard electric motors. Also will exhibit a Variable Reduction Gear, having infinite variability and being especially designed for a stoker drive. Also showing a line of Clutches.

Universal Packing Corp'n **408**
108 Smith St., Pittsburgh, Pa.

Van Dorn & Dutton Co. **604**
2990 Woodhill Road, Cleveland, Ohio.

Van Dorn Electric Tool Co. **512, 513**
Cleveland, Ohio
Will have in operation: Electric Hammers, drilling, chipping and breaking concrete. Electric Screw-drivers and Nut Runners Driving screws in wood and tightening bolts and nuts. Also Electric Drills in various capacities drilling in iron and steel. In addition there will be on exhibit the balance of the Van Dorn Line of Portable Electric Grinders, Tappers, Drills, Reamers and Accessories.

Veeder-Root (Inc.) **234**
20 Sargent St., Hartford, Conn.
Will exhibit the following instruments; Mechanical and Magnetic Counters for recording production on all types of manufacturing machines; Counters for use in offices on Typewriters, Billing Machines, Adding Machines, Sorting Machines and also counters for many other purposes, such as Speed Counters and Hand Tally Counters.

Vogt, Henry, Machine Co **266**
10th & Ormsby Sts., Louisville, Ky.
See Adv. Pages 118, 119

Will exhibit their regular line of Drop Forged Steel Valves and Fittings for high pressure and temperature service.

Vulcan Soot Cleaner Co. **213**
Du Bois, Pa.
Will show various parts of our Vulcan Soot Cleaner, including our type "H," self-contained Vulcan Valve Operating Head, as well as elements for various temperatures. These will include Chrome Alloy Crodon elements for the most severe temperature conditions, Crodon for the low temperature portions of the boiler.

Wallace, J. D., & Co. **637**
156 S. California Ave., Chicago, Ill.
Will exhibit a working demonstration of their Wallace Line of Portable Woodworking Machines which are extensively used in all branches of the woodworking industry and in the manual training shops of schools and colleges. Will also exhibit and demonstrate this "Workace" Line of motor driven machinery for the home workshop and light intermittent industrial use.

Walworth Co. **477, 478, 491, 492**
Statler Bldg., Boston, Mass.
Will show four main lines of products.

Booth

These lines are Sigma Steel Valves and Fittings for high-pressure, high-temperature steam service; Bronze Valves; Chrome-Nickel-Iron Pipe and Stillson Wrenches.

Warren, Killion & Clark Co. **413**
30 Church St., New York, N. Y.
Representing: Strong, Carlisle & Hammond Co. and Frank H. Schaefer Co.

Watts Regulator Co. **39**
254 Lowell St., Lawrence, Mass.
Will show Watts U-Tube Interchanger, Watts Type 35 Auxiliary Pressure Regulator, Type 1, 2, 5 Pressure Reducing Valves, Type 9–10–11 Pump Governors, also line of Pressure Relief Valves, Damper Relief Valves and Hot Water House Heating Units and Water Pressure Reducing Valves. Will have under actual demonstration the Watts Type 40 Temperature Pressure Relief Valve.

Webber, F. M., Co. **624, 625**
420 Lexington Ave., New York, N. Y.
Exhibiting various sizes and types of Charavay Airplane Propeller Fans and Blowers. Exhibit will be wired so that Fans and Blowers can be operated.

Webster, Warren & Co **225, 226**
Camden, New Jersey
Will exhibit equipment used in connection with Webster Vacuum, Webster Type 'R' and Webster MODERATOR Systems of Steam Heating also Webster Series '78' Traps used in conjunction with process steam equipment and systems of steam circulation.

Westinghouse Elect. & Mfg. Co. **68, 487, 488**
East Pittsburgh, Pa.
See Adv. Pages 120, 121, 130

Booth 68 will be devoted to the exhibition of a working model of the Link-Grate Multiple Retort Stoker. This is the latest design of stoker for large boilers and heavy sustained loads. Booths 487 and 488 will be devoted to the exhibition of a Westinghouse 150 Hp. type "AMD" mechanical drive turbine. This is the latest design of mechanical drive turbines for driving circulating pumps, centrifugal boiler feed pumps, blowers and other rotary apparatus. They may be connected to the driven machinery either directly, or through the medium of reduction gears. The centrifugal type speed regulating governor is used, as well as a positive acting emergency overspeed governor. The glands are water sealed to prevent steam leakage from the cylinder. Bronze nozzles and brass reversing chambers are used together with a balanced bronze inlet valve, controlled directly by the governor. The turbine casting is usually made of cast iron, but for special steam conditions cast steel is employed. It is split on the horizontal centerline and both the steam inlet and exhaust connections are made to the lower half of the cylinder, thus eliminating the necessity of breaking steam joints when raising the cover for inspection of turbine interior.

Weston Electrical Instr. Corp'n **600**
614 Frelinghuysen Ave., Newark, N. J.
Will exhibit a representative group of Electrical Indicating Instruments, both portable and switch-board A.C. and D.C. types. A feature of the exhibit will be a display of a set of Miniature A.C. Testing Instruments, together with the new but popular Weston Model 539 Portable Current Trans-former.

Wheeler, C. H., Mfg. Co. **77**
Lehigh and Sedgley Aves., Philadelphia, Pa.
Several types of Radojet Air Pumps will be exhibited together with numerous pictures and photographs descriptive of the C. H. Wheeler Dual Bank Surface Condenser and other equipment as furnished to power plants, oil refineries, sugar refineries and other industrial plants.

Wheland Co. **295**
Chattanooga, Tenn.
Manufacturers of the Biggs Underfeed Stoker. This machine is the center retort, side sump type and from 50 H.P. to 500 H.P.

Whitney Metal Tool Co. **454, 455**
110 Forbes St., Rockford, Ill.
Exhibiting a line of Metal Working Punches, Shears and Angle Iron Machinery.

Williams Tool Corp'n **567, 568**
Erie, Pa.
Exhibit will consist of one No. 6 Williams

Booth

Rapiduction Pipe Threading and Cutting Machine, capacity 1 to 6". Will also exhibit a new line of "Wilco" pipe threading machines, capacity ⅛ to 4". This machine uses high speed dies only. Will also exhibit the Williams Portable Pipe Threading Machine, capacity ¼ to 2". This machine will thread pipe up to and including 8" using universal shaft to drive the geared handstock.

Wing L J Mfg Co **61**
188 W 14th St., New York, N. Y.
See Adv. Page 93

Will exhibit the following products: Turbine Blower, for forced draft,—for stokered and hand-fired boilers; Steam turbine, capacity up to 50 hp. for driving pumps, fans, etc.; Centrifugal turbine blower, for blowing gas producers, etc.; Compressed Air driven Turbine Blower for mine ventilation; Motor driven forced draft Blower for low pressure boilers; Wing Featherweight Unit Heater, for all types of plants.

Wood, Alan, Steel Co. **536**
Conshohocken, Pa.
Will demonstrate this Standard "A" Diamond and "AW" Diamond-ette Rolled Steel Floor Plates for all types of steel floorings, runways, cover plates, etc. The main features of this "AW" Floor Plate are its adaptability to power plant flooring, platforms, etc.

Woodworking Machinery Co. **638**
250 No. 11th St., Philadelphia, Pa.
Will exhibit a complete line of Ball Bearing Woodworking Machinery. The ELECTRIC CARPENTER is a combination machine consisting of Band Saw, Circular Saw, 6" Jointer, Hollow Chisel Mortiser, Vertical Shaper and Lathe combined in one machine. Weighs 600 lb. The GREYHOUNDSLIDE SAW. Weighs 275 lb. Readily portable on the building operation. Beltless, ball-bearing throughout. A parallel swing saw that will also rip, dado and can be used as a vertical shaper. Single purpose machines: A complete line of Band Saws, Jointers, Lathes, etc.

Wright-Austin Co. **28**
315 W. Woodbridge St., Detroit, Mich.
Will exhibit their regular line of steam traps, three types, water columns with trimmings, steam separators, exhaust heads, pump governors and feed water regulators, but will lay special stress on their new "Airpel" Trap, which has been out now about one year and the "Kleervu" Gauge Glass Protector and the "Crescent" Trycock.

Wright Mfg. Co. **346, 347**
Bridgeport, Conn.
Exhibit will show Wright Hoists. A movable display will show a new display stand we are bringing out, on which to display Wright Hoists in any show room.

"X" Laboratories **256**
25 W. 45th St., New Yorl., N. Y.
Will demonstrate "X" Boiler Liquid, for quickly and permanently repairing all leaks, in steam and hot water, high and low pressure heating systems.

Yale & Towne Mfg. Co. **425, 426**
Stamford, Conn.
Exhibit will consist of Yale Material-Handling Equipment, including electric industrial trucks, tractors and trailers, Yale chain blocks, electric hoists, overhead traveling cranes and motor driven trolleys. Several new additions to their material-handling line will be on display including the Yale Model K24C four wheel steer, four wheel drive, heavy duty electric industrial tractor, the Yale Model K26, 6 wheel steer. 5-ton capacity, low lift elevating platform truck, also the new Yale Motor Driven Trolley.

Yarnall-Waring Co. **24**
Chestnut Hill, Philadelphia, Pa.
Will exhibit: A full line of YARWAY Seatless and Double Tightening Blow-Off Valves for all pressures up to 1800 lbs., including forged steel valves for both boiler blow down and water wall drain service. Various types of YARWAY Floatless Hi-Lo Alarm Water Columns and Sesure Inclined Gates. A new development in flat glass gage design will be exhibited for the first time. In addition to above will have on display—YARWAY Spray Nozzles, Hydraulic Operating Valves and Pipe Clamps.

BOOTHS 545-546—NEW YORK POWER SHOW—DEC. 2 to 7

QUALITY CONTROLLED

An attainment of the manufacturing processes of The Garlock Packing Company

GARLOCK-353 Oilblack Rubber Sheet is one of the resultant products of the Quality Controlled Processes of The Garlock Packing Company. This commodity was developed after years of laboratory and field experiments to fill the demand for a sheet packing that would resist the deteriorating action of oils.

The manufacturing of Oilblack Rubber Sheet Packing, from the compounding through the mixing of the batch on the rubber mills, the calendering, vulcanization and inspection, is supervised by Garlock Craftsmen. These skilled workers receive their training through many years of service in the Garlock Factories.

The crude materials used in producing GARLOCK-353 have to meet our standards, by laboratory test, before acceptance.

Oilblack Rubber Sheet Packing will give economical service when used against heavy or light oils, hot or cold water, steam, ammonia and alkali solutions.

At the New York Power Show
Booths 545 and 546
Let our Exhibit be your headquarters

The Garlock Packing Company
Manufacturers of Mechanical Packings
Palmyra, N. Y., U. S. A.

BOOTHS 554-555—NEW YORK POWER SHOW—DEC. 2 to 7

Shown at the Power Show

TROY SELF-OILING STEAM ENGINES

Better Speed Control—Dust Proof Construction

TROY Engines are sturdily built and well adapted for driving fans, blowers, centrifugal pumps, various process machinery, stokers in institutions, office buildings, etc. (exhaust steam is available for heating and hot water supply), or for driving generators as main units or as auxiliary equipment.

200 lb. working pressure guaranteed—special cylinders for 250 lb. working pressure and high superheat.

TROY ENGINE & MACHINE CO.
TROY, PENNA.

118 W. Ohio St., Chicago, Ill.
Distributors for Canada
Riley Equipment & Supply Co., Ltd.
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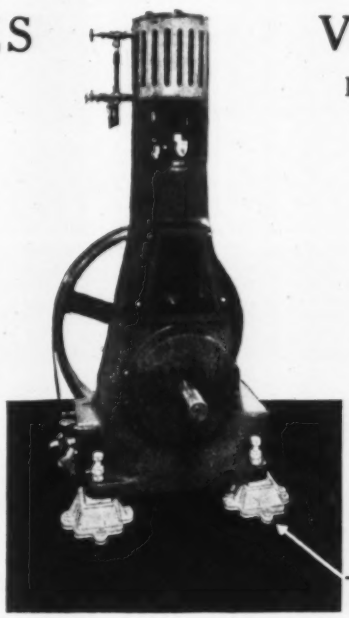
Write for TROY ENGINE CATALOG—if you cannot visit the Power Show

MOUNTED ON



KORFUND VIBRO-DAMPERS

Endorsed by leading Engineers to isolate Machine Vibration

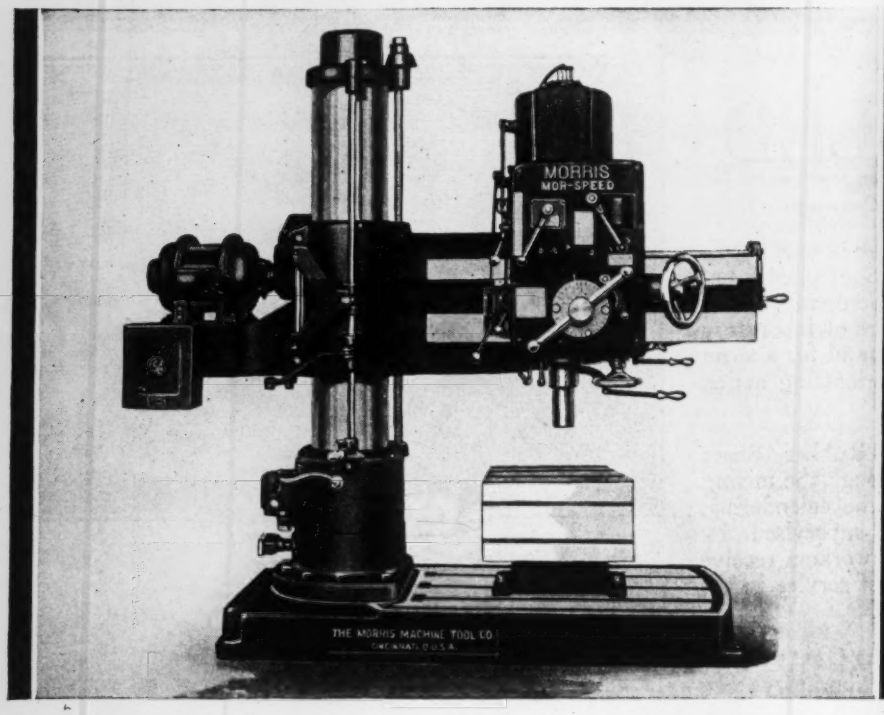
At the POWER SHOW we exhibit a TROY ENGINE mounted on KORFUND VIBRO-DAMPERS and running at regular speed.

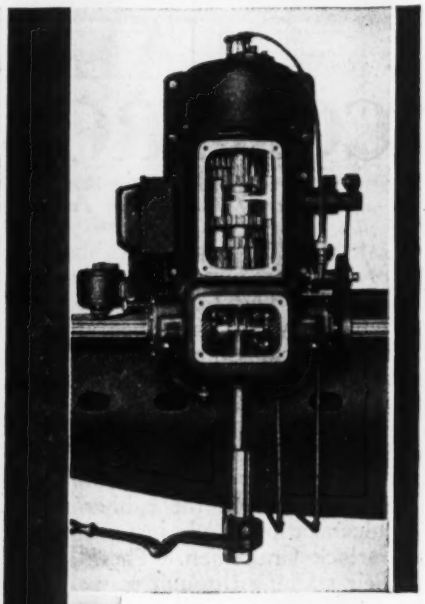
KORFUND VIBRO-DAMPERS are particularly effective for isolating vibration and noise of machines which work with heavy and sudden impacts, machines of high rotative speeds and machines having excessive humming noises.

The KORFUND CO., Inc.
235 East 42nd St., New York

In case you cannot visit the Power Show write for Bulletin on the KORFUND VIBRO-DAMPER or the new Bulletin A on KORFUND BASE.

BOOTHS 604-605—NEW YORK POWER SHOW—DEC. 2 to 7





G & F Gears are used in Morris Machine Tools

Exacting Quality-Absolute Accuracy *characterize these* GEARS

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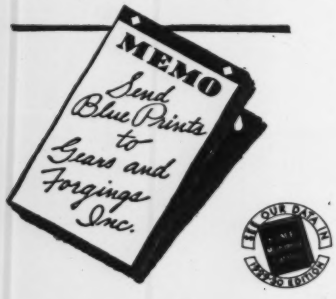
Drop, Flat Hammer and Upset Forgings, Cut Gears
Speed Reducers
Rolling Mill Machinery
Special Machinery



EXACTING quality and absolute accuracy have become traditions in the machine tool industry. The fact that G & F gears are now being used by many of the larger machine tool manufacturers is a tribute to the efficiency of our methods and the quality of our product.

The Mor-Speed Radial Machine is a typical example of the use of G & F gears in a machine tool. All gears are cut from forgings supplied by our own Forge Division. They are hardened and broached, with heat treated splines, shafts and spindles. Speed and feed changes in this machine are located in the head, the entire unit running in oil.

The engineers who design G & F gears are experts in gear design and construction. The actual production is carried out by highly skilled operators. Then comes careful inspection and rigid tests. Such a combination of facilities enables us to successfully meet your most exacting demands for machine tool gears. Send us specifications for your next job.

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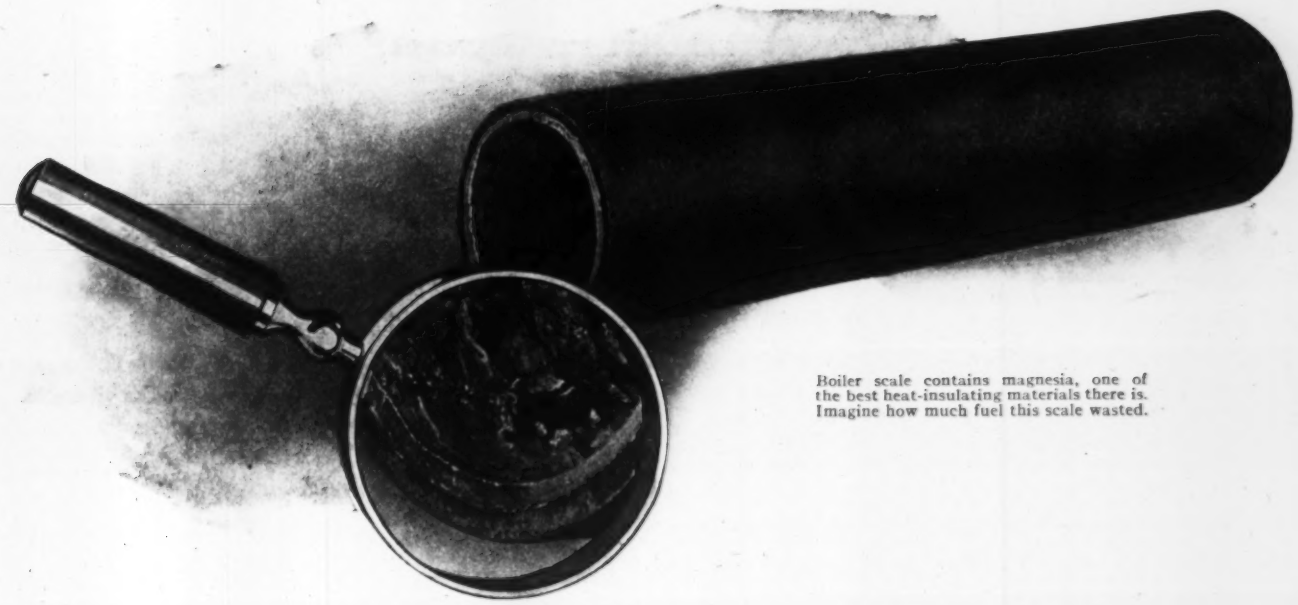


Boiler scale contains magnesia, one of the best heat-insulating materials there is. Imagine how much fuel this scale wasted.

1/8 inch of scale every two weeks

before soft water was used

THE chief engineer of a certain Los Angeles manufacturing plant was troubled for many years by boiler scale. He had a hard problem to contend with because his water supply came from a deep well and contained a lot of scale-forming minerals. In addition, his 350 h.p. Hawkes boiler was operated at high rating on shavings for fuel, and the hot spotty fire was continually burning out boiler tubes.

Scale formed so rapidly in the tubes that it deposited 1/8 inch thick in two weeks' time, causing frequent turbining, which had to be done on Sundays. Boiler compounds of various kinds were unable to overcome the difficulty.

Realizing that boiler repair and maintenance was costing entirely too much and that the water supply was the base of the trouble, two Permutit Water Softeners were installed. The company wrote us as follows as to their experience:

"We were having a great deal of trouble from boiler scale, and finding it necessary to wash the boiler once a week, with loss of time due to tube replacements and such. Since installing Permutit Equipment we have had no scale, and much more soft water than we were promised. The replacement of tubes and other boiler repairs has been steadily decreased, while the operation of the boiler and plant has been 100% more efficient. Permutit has solved our boiler scale problem and we are glad to recommend it to those who are having this trouble."

It will pay you to know more about this subject of water supply—to learn what the experience of other chief engineers has been. Our booklet, "Reducing Fuel and Boiler Plant Operating Costs," covers the subject fully. It is authoritative and answers many of the day-to-day problems you meet in your work. Send for a copy of this free booklet to-day. There is no obligation.

The Permutit Company

APPARATUS FOR REMOVING IMPURITIES FROM WATER

MAIN OFFICE: 440 FOURTH AVENUE, NEW YORK—

The Permutit Company
440 Fourth Ave.
New York

Please send me your free booklet "Reducing Fuel and Boiler Plant Operating Costs."

Name..... Position.....

Company.....

Address.....

A.S.M.E. 1929 Annual Meeting Program

New York, December 2 to 6, 1929

(The Conference of the Local Sections Delegates will begin Sunday, December 1, at 2:00 p.m.)

Monday, December 2, 9:30 A.M.

Council Meeting.
Conference of Local Sections Delegates.
Simultaneous Sessions on.

Hydraulic Power
Power—Steam or Hydro or Both, WM. W. TEFFT.
Increased Kilowatt Output of Adjustable-Blade Propeller Turbines, C. R. MARTIN.
Mechanical Vibrations in Penstocks of Hydraulic-Turbine Installations, J. P. DEN-HARTOG.

Applied Mechanics (I)
Factor of Safety and Working Stress, C. RICHARD SODERBERG.
The Mechanics of the Plastic State of Metals, A. NADAI.
1:00 P.M. Luncheon of Council and Local Sections Delegates.
2:00 P.M. Simultaneous Sessions

Machine-Shop Practice
Quality Control and Production Gages, EARLE BUCKINGHAM.
Progress Report of Machine-Shop Practice Division.

Hydraulic Turbines
Changing Requirements in Hydraulic Turbine Speed Regulation, FORREST NAGLER.
Mechanics of Hydraulic-Turbine Pressure Regulation, A. PFAU
Progress Report of Hydraulic Division.

Applied Mechanics (II)
Torsional Vibration Dampers, J. P. DEN-HARTOG and J. ORMONDROYD.

Power Test Codes Public Hearing
Test Code for Liquid Fuels.
2:15 P.M. Conference of Local Sections Delegates.
2:30 P.M. Council Meeting.
8:00 P.M. Business Meeting.
8:30 P.M. Open House.
Ladies Annual Get-Together.

Tuesday, December 3, 9:30 A.M.

Conference of Local Sections Delegates.
Simultaneous Sessions on

Fuels
Soot Particles in New York City Air, E. E. FREE.
Progress Report of Fuels Division.

Materials Handling (I)
The Application of Aerial Tramways to Long and Short Hauls, M. P. MORRISON.
Progress Report of Materials Handling Division.

Applied Mechanics (III)
Natural Frequency of Gears, R. E. PETERSON.
The State of Stress in Full Heads of Pressure Vessels, W. M. COATES.
2:00 P.M. Simultaneous Sessions.

Economics of Delivery Vehicles
Economic Aspects of Gasoline-Operated Commercial Vehicles, R. E. PLIMPTON.
Discussion on the Economics of Delivery Service.

Cutting Metals—Jointly with Machine Shop Practice Division
Turning with Shallow Cuts at High Speeds, H. J. FRENCH and T. G. DIGGES.
Power Required to Drill Cast Iron and Steel, O. W. BOSTON and C. J. OXFORD.
A Test Code for High-Speed Steel for Turning Tools, L. H. KENNEY. Report of Sub-Committee D on Properties of Materials of the Special Research Committee on Cutting of Metals.
Present Practice in the Use of Cutting Fluids, S. A. MCKEE.
Progress Report No. 2 of Sub-Committee on Cutting Fluids.

Mechanical Springs
The Radially Tapered Disk Spring, W. A. BRECHT and A. M. WAHL.
Present Status of the Mechanical-Spring Art, J. K. WOOD.
Elastic and Inelastic Behavior in Spring Materials, M. F. SAYRE.
Fifth Progress Report of Special Research Committee on Mechanical Springs.
2:15 P.M. Conference of Local Sections Delegates.
8:30 P.M. Report of Nominating Committee.
Introduction by President-Elect.
Engineers in American Life, L. W. WALLACE and J. E. HANNUM.
Reception and Dance.

Wednesday, December 4, 9:30 A.M.

Simultaneous Sessions on

Use of Engineering Literature
What the Engineering Societies Library Does for Engineers, HARRISON W. CRAVER.
The Value of Engineering Periodical Literature, J. E. HANNUM.

Department Management
Management of Service Department, Budgeting and Wage Incentive Applied to a Large Organization, WILLIAM B. FERGUSON and TOM H. BLAIR.

Wednesday, December 4 (Continued)

Lubrication—Jointly with Machine-Shop Practice Division
Performance of Oil-Ring Bearings, GEORGE B. KARELITZ.
The Service Characteristics of Diesel Engine Lubricating Oil, A. E. FLOWERS and M. A. DIETRICH.
2:00 P.M. Simultaneous Sessions on

Education and Training for the Industries of Non-College Type
Report on the Study of Non-College Technical Education, W. E. WICKENDEN.
Suggestions for Encouraging Education and Training for Industry, H. S. FALK.

Student Branches
Steam Tables Research
6:30 P.M. Annual Dinner, Hotel Astor.

Thursday, December 5, 9:30 A.M.

Simultaneous Sessions on

Symposium on Production Management
Advantages Derived from the Simplification of the Fundamental Formulas for Economic Production Quantities, FAIRFIELD E. RAYMOND.
Twelve Years' Experience with Economic Production Quantities, C. H. BEST.
The Use of Economic Manufacturing Quantities, ROBERT W. KENT.

Central-Station Power
Progress Report of Power Division.
The Effect of Large Boilers Operated at High Capacities on the Operating Characteristics and Investment Costs of Boiler Plants, F. S. CLARK.
Performance of Modern Steam-Generating Units, C. F. HIRSHFELD and G. U. MORAN.

Railroad (I)
Locomotive Auxiliary Power Mediums, GEORGE W. ARMSTRONG.
High-Pressure Locomotives, A. F. STUEBING.
Progress Report of Railroad Division.

Oil and Gas Power
Progress Report of Oil and Gas Power Division.
The Gas Engine and Its Application in Oil-Field Engineering, GEO. L. REID.
Progress Report of Special Research Committee on Diesel Fuel Oil Specifications.
2:00 P.M. Simultaneous Sessions.

Railroad (II)
Heat Transfer in the Locomotive Superheater, LAWFORD H. FRY.
Metallurgy in the Railroad Field, CHARLES MCKNIGHT.

General
Working Stresses for Steel at High Temperatures, D. S. JACOBUS.
A Study of Tin-Base Bearing Metals, G. B. KARELITZ and O. W. ELLIS.

Symposium on the Application of Geometrical Similarity and Dimensional Analysis in Fluid Flow
Quantity-Rate Fluid Meters, ED. S. SMITH, JR.
Similarity: Limitations in Its Application to Fluid Flow, J. M. SPITZGLASS.
The Flow of Fluids Through Orifices in 6-In. Pipe, S. R. BEITLER and PAUL BUCHER.
Reports of the Sub-Committees of the Fluid Meter Committee.
3:00 P.M. Ladies Annual Tea.
Evening College Reunions.

Friday, December 6, 9:30 A.M.

Council Meeting.
Simultaneous Sessions on

Boiler Feedwater Studies
Recent Instances of Embrittlement in Steam Boilers, FREDERICK G. STRAUB.

Aeronautics
Recent Developments in Aircraft Engine, JOHN H. GEISSE.
Factors in the Design of Commercial Airplanes, CHARLES T. PORTER.
Progress Report of Aeronautic Division.

Textiles
General Design and Operating Features of Range or in-Train Drives for Finishing Plants, WENDELL S. BROWN.
Progress Report of Textile Division.
2:00 P.M. Simultaneous Sessions on

Rail-Motor Cars (Railroad and Oil and Gas Power Divisions Jointly)
The Design and Application of Rail-Motor Cars, C. O. GUERNSEY.
Discussion on Rail-Motor Car Maintenance.

Refrigeration (Jointly with A.S.R.E.)
Thermodynamics of Air Cooling, BARTON H. COFFEY (contributed by A.S.R.E.)
Engineering Computations for Air and Gases, SANFORD A. MOSS and C. W. SMITH

Furniture Production
From the Master Cabinetmakers to Woodworking Machinery, J. D. and MARGARET S. WALLACE.
Modern Method of Manufacturing Classical Furniture, HARRY KIMP.
Progress Report of Wood Industries Division.

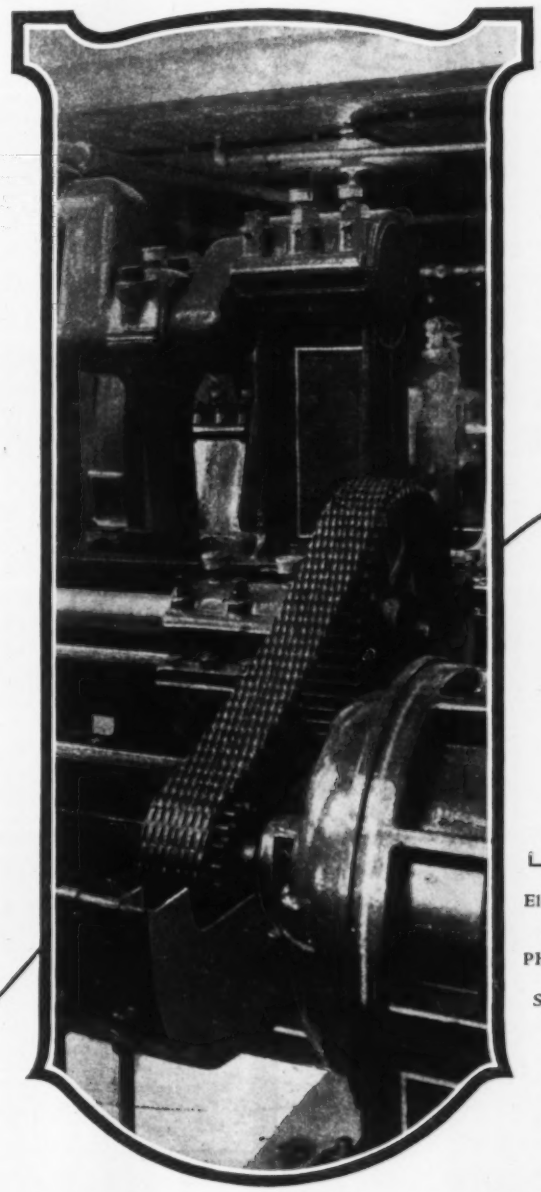
. . . The nearest thing to perfection in smooth, positive, unfailing power transmission

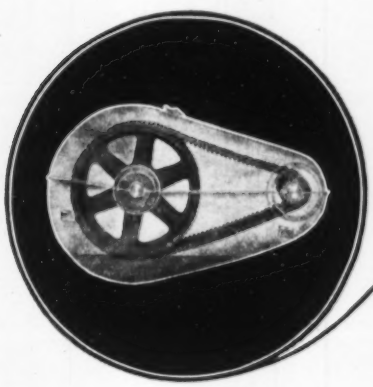
Link-Belt Silent Chain is selected by many users because of its ability to transmit power at uniform, sustained speeds, without loss or slip, materially helping in maintaining the maximum production, and making a high grade product.

Truly, Link-Belt Silent Chain is the nearest thing to perfection in smooth, positive, unfailing power transmission. It is flexible as a belt—positive as a gear—more efficient than either. It operates on short or long centers, and when enclosed in a Link-Belt dust-proof, oil-retaining, safety casing, makes an ideal drive.

Send for Silent Chain Drive Data Book No. 125.

Drives ½ to 60 H.P. carried in stock by distributors in many cities for immediate delivery.





LINK-BELT COMPANY
Leading Manufacturers of
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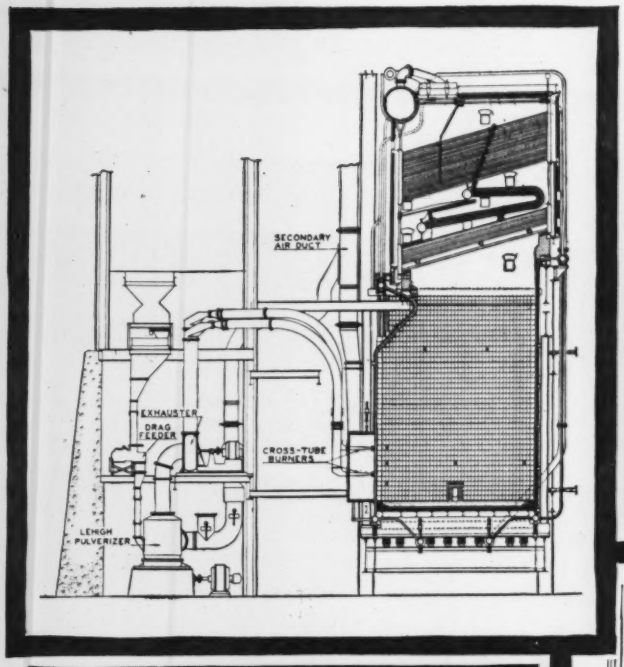
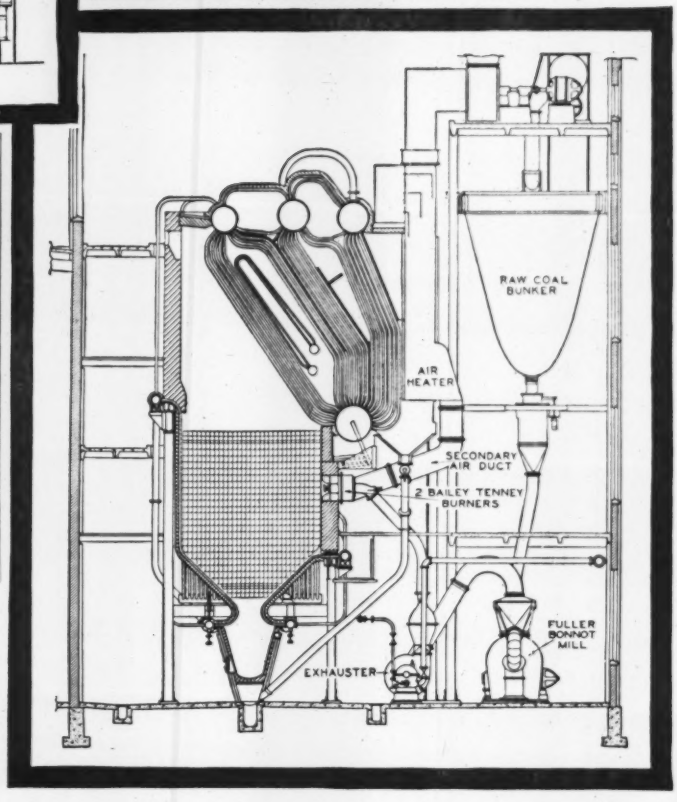
LINK-BELT
SILENT CHAIN DRIVES

BOOTH 54—NEW YORK POWER SHOW—DEC. 2 to 7

FULLER LEHIGH



The illustration at the left is a layout of the Fuller Lehigh Direct-Fired System with Bailey Slag-Tap Furnace for a large central-station boiler designed for 350,000 lb. of steam per hr.



At the right is the layout of the Fuller Lehigh Direct-Fired System with Bailey Hopper-Bottom Furnace in an industrial plant. The steaming capacity of this boiler is 90,000 lb. of steam per hr.

FULLER

DEVELOPMENTS In Pulverized-Coal Firing

AMONG the noteworthy advances in pulverized-coal firing accomplished by the Fuller Lehigh Company during recent years are: (1) The development of basically sound principles of coal pulverization; (2) The application of the direct-fired system to boiler units of all sizes and (3) The development of burners and furnaces which permit the full advantages of pulverized-coal firing to be realized in boiler units of practically all capacities.

PULVERIZATION—There are no parts requiring lubrication within the grinding zone of Fuller Lehigh Pulverizing Mills and the fineness of pulverization is not affected by wear of the grinding parts. Recent developments have been along the line of smoother operation, greater capacity, lower power consumption and the application of constant-speed drive for direct-fired installations.

DIRECT-FIRING—The Fuller Lehigh System of Direct Firing including its Turbulent Burners and Water-Cooled Furnace Construction is accepted as a most desirable system for boiler units of practically all capacities. It is clean, simple, reliable and easy to operate.

BURNERS—Turbulent burners, sponsored and developed to a high degree by the Fuller Lehigh Company, are a major development in the evolution of pulverized-coal firing, involving not only the principles of burner design, but also the proper co-ordination of pulverizing, feeding and furnace equipment.

FURNACES—Bailey Water-Cooled Furnace Construction has contributed much to the development of pulverized-coal firing by meeting the requirements of high capacity, high availability and high efficiency with smokeless combustion over a wide range of heat liberation. Other but not less important features are low maintenance and ease of ash removal. The Bailey Slag-Tap Furnace is a relatively recent development which is being widely adopted for pulverized-coal fired installations.

The high standards of research, engineering and service behind all Fuller Lehigh Products and Installations have earned for them an enviable reputation for satisfactory performance.

Details of these developments both as to construction and application may be seen at our Booth No. 54 at the New York Power Show.

FULLER LEHIGH COMPANY, FULLERTON, PENNA.

A BABCOCK & WILCOX ORGANIZATION

1—1537

LEHIGH

PULVERIZED-COAL EQUIPMENT — WATER-COOLED FURNACE WALLS

BOOTH 247—NEW YORK POWER SHOW—DEC. 2 to 7

BARCO Lubricated Plug Valves

Barco Lubricated Plug Valves are lubricated to provide ease of operation and long life of the wearing parts and are not dependent on the lubricant as they will be absolutely tight with no lubricant whatever.

Double gland arrangement allows the packing to be renewed if necessary under pressure with no danger of the valve blowing out. One set of packing prevents steam leakage and provides adjustment of the plug in the body at the proper tension for the pressures used.

These valves are furnished with steam jackets for hot asphalt, tar, etc.

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1929-30 EDITION

Barco Manufacturing Company, 1801 Winnemac Avenue, Chicago, Illinois

BOOTH 257—NEW YORK POWER SHOW—DEC. 2 to 7

In its place, and using the right compound in the right place, *Graphite* has no equal.

It has been the accepted privilege of the Joseph Dixon organization to spread the gospel of the proper use of *Graphite* and *Graphite Compounds* to the end that maintenance cost may be held at a minimum thru the better operation and longer service that each Graphite protected part must render.

MOTOR BRUSHES BOILER GRAPHITE
CUP GREASE PIPE JOINT COMPOUND
FLAKE GRAPHITE SILICA-GRAPHITE PAINT
WATERPROOF GREASE
for maintenance-
DIXON'S
GRAPHITE
PRODUCTS

better lubrication; the *Boiler Graphites* for cleaning steam boilers; the Graphite Pipe Joint Compounds; the Silica-Graphite Paint with years of service on so many thousands of jobs; and Dixon's Belt Dressing, a non-graphite product which prevents belt slippage and increases power thru its use on leather, rubber, and fabric belts. Also DIXON'S Solid Belt Dressing.

Engineers find in Dixon's Line products of unusual merit. The carefully graded *Flake Graphites*—each with its special uses; the exactly compounded *Graphite Greases*, each with its place in every scheme of

Dixon's engineers and research men have a background of 100 years of continuous service to draw from. They are at your service to give you the benefit of our wide and varied experience.

See Our Exhibit *Booth 257* N.Y. POWER SHOW

JOSEPH DIXON CRUCIBLE CO.

Jersey City D×N TRADE MARK New Jersey

ESTABLISHED 1827

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Costs are lower when you build arc barriers with

TRANSITE

LIGHT in weight, fireproof, and having high arc resistance, Johns-Manville Transite saves money because it makes expensive and cumbersome concrete and masonry construction unnecessary. Mounted on easily erected steel framing, Transite permits installations on balconies and overhead platforms which could not support heavier construction.

Where heavy currents must be handled with safety, Transite gives the maximum protection against damage by arcing. Because of absence of laminations in its structure, Transite is uniformly strong and offers a constant, maximum resistance both to sudden mechanical shocks and to stresses due to temperature change. Transite can be made to fit any desired shape. It is easy to erect—it is easy to add to or to modify—and, in addition, if equipment rearrangement becomes necessary, practically all the Transite construction may be salvaged.

SEE OUR DATA IN A.S.M.E. Handbook 1928 EDITION

Johns-Manville

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JOHNS MANVILLE CORPORATION

JOHNS-MANVILLE CORPORATION
New York, Chicago, Cleveland, San Francisco, Toronto
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Please send me information regarding the uses of Transite for arc barriers, heat-resisting mountings and general fireproof construction.

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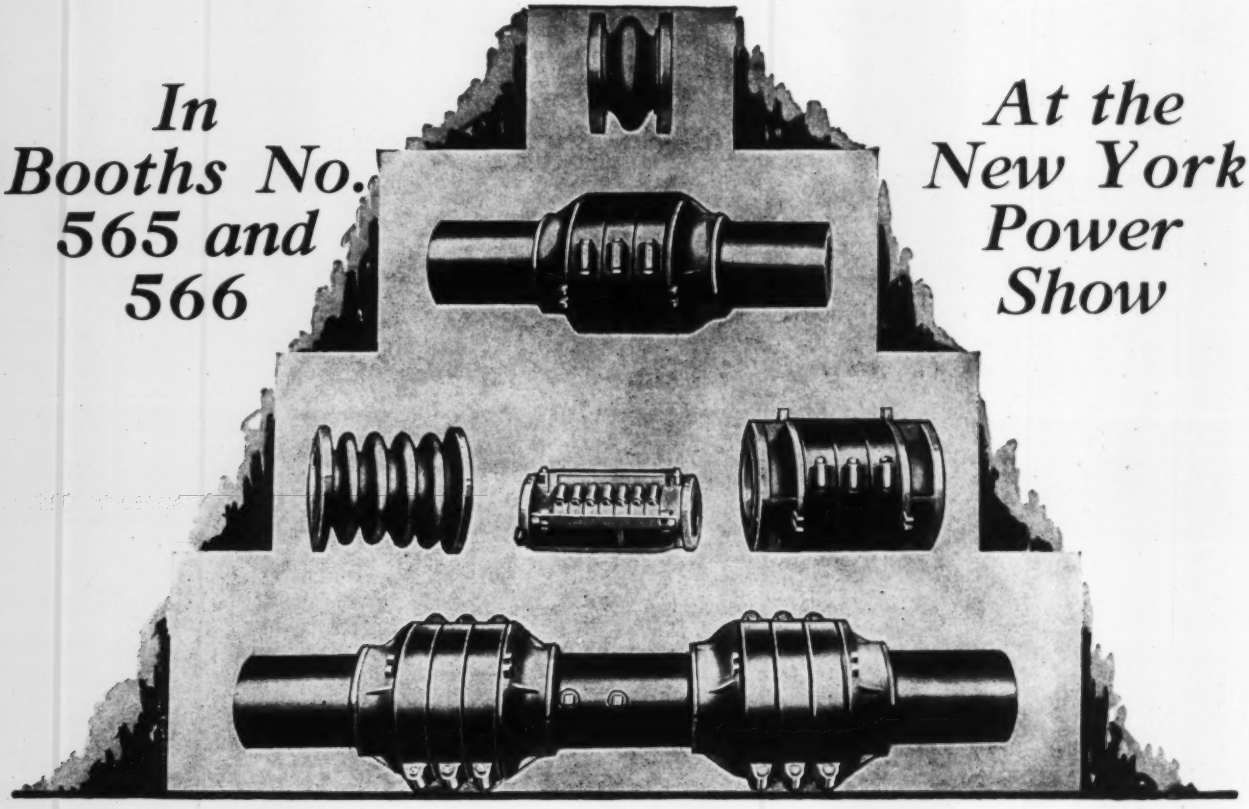
BOOTHS 565-566—NEW YORK POWER SHOW—DEC. 2 to 7

EXHIBITING

In Booths No. 565 and 566



At the New York Power Show

Here's an Opportunity to study the *Installation* and *Insulation* of Badger Expansion Joints

IN SO far as it is practical to do so, double unit, commercial size Badger Self Equalizing Expansion Joints will be shown as they would be actually installed with anchors, guides and service outlets. Both the flanged and welded end type units will be used.

And in addition, they will be insulated to indicate that there need be no condensation losses at the joints.

For those operators who have other expansion joint problems, there will be available for study the low pressure Badger Joints and those designed particularly for superheated steam.

Your inspection of these Badger Joints will be most welcome. Come in and study them and let our engineers advise you as to their application to your expansion problem.

E. B. BADGER & SONS COMPANY

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New York, N. Y., 271 Madison Ave.
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Minneapolis, Minn., 716 Build. Exch.
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Atlanta, Ga., Red Rock Bldg.
Salt Lake City, Utah, Kearns Bldg.

Philadelphia, Pa., 1500 Walnut St.
Detroit, Mich., 1728 Ford Bldg.
St. Louis, Mo., 3605 Laclede Ave.
Houston, Tex., 1308 Sec. Nat. Bk. Bldg.
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Pittsburgh, Pa., Union Trust Bldg.
Montreal, Que., Can., Cement Bldg.
Los Angeles, Cal., 517 Hollingsworth Bldg.
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BADGER EXPANSION JOINTS

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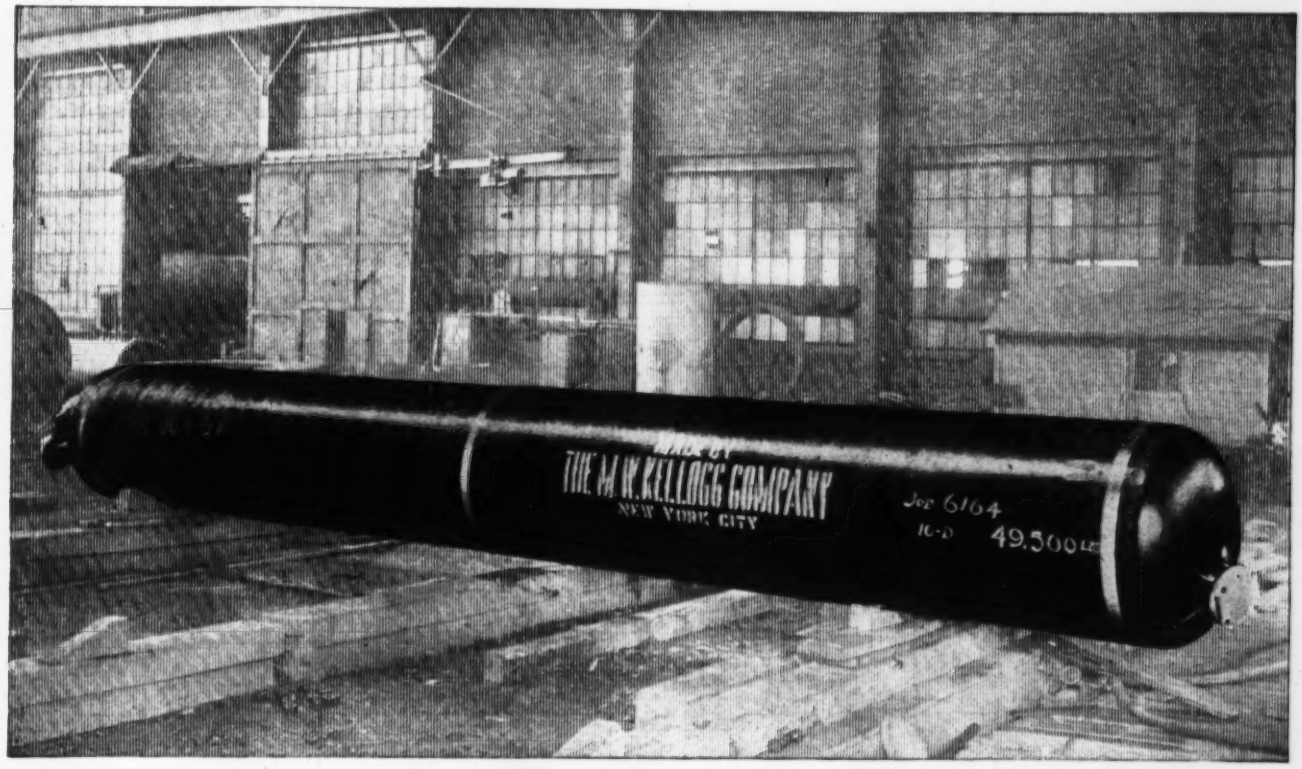


Kellogg Forge Welded Mud Drum for the J. H. Reed Sta., Duquesne Light Co., Pittsburgh, Pa. [redacted] I.D. x 2 33/64 in. thick x 33 ft. 3 1/8 in. overall. Byllesby Eng. and Management Corp., Engineers

Kellogg Boiler Drums and Pressure Vessels

are serving leading power producers

POWER engineers throughout the country are constantly planning to provide equipment which will operate at the lowest ultimate cost. In Kellogg boiler drums and other pressure vessels, many of these engineers have already found the required qualities, and through experience are now specifying additional Kellogg equipment to meet new power demands.

The Kellogg forge welded drum, illustrated, is one of twelve installed in the J. H. Reed Station of the Duquesne Light Company. This adds another unit to the Kellogg products already in service, and demonstrates the satisfaction experienced by the operating and management engineers.

You are cordially invited to visit the Kellogg booth at the Power Show, where you will find full information on Kellogg power products, and an impressive record of Kellogg installations.

THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK

Birmingham	827 Brown-Marx Building	Dallas	714 Kirby Building
Boston	12 Pearl Street	Pittsburgh	Oliver Building
Chicago	53 W. Jackson Boulevard	Los Angeles	742 Western Pacific Building
Tulsa	Philtower Building		

KELLOGG

FORGE AND HAMMER LAP WELDED AUTOCLAVES...BOILER DRUMS...DIGESTERS...HEADERS...RECEIVERS...SEPARATORS...FLANGED JOINTS...CENTRAL STATION PIPING

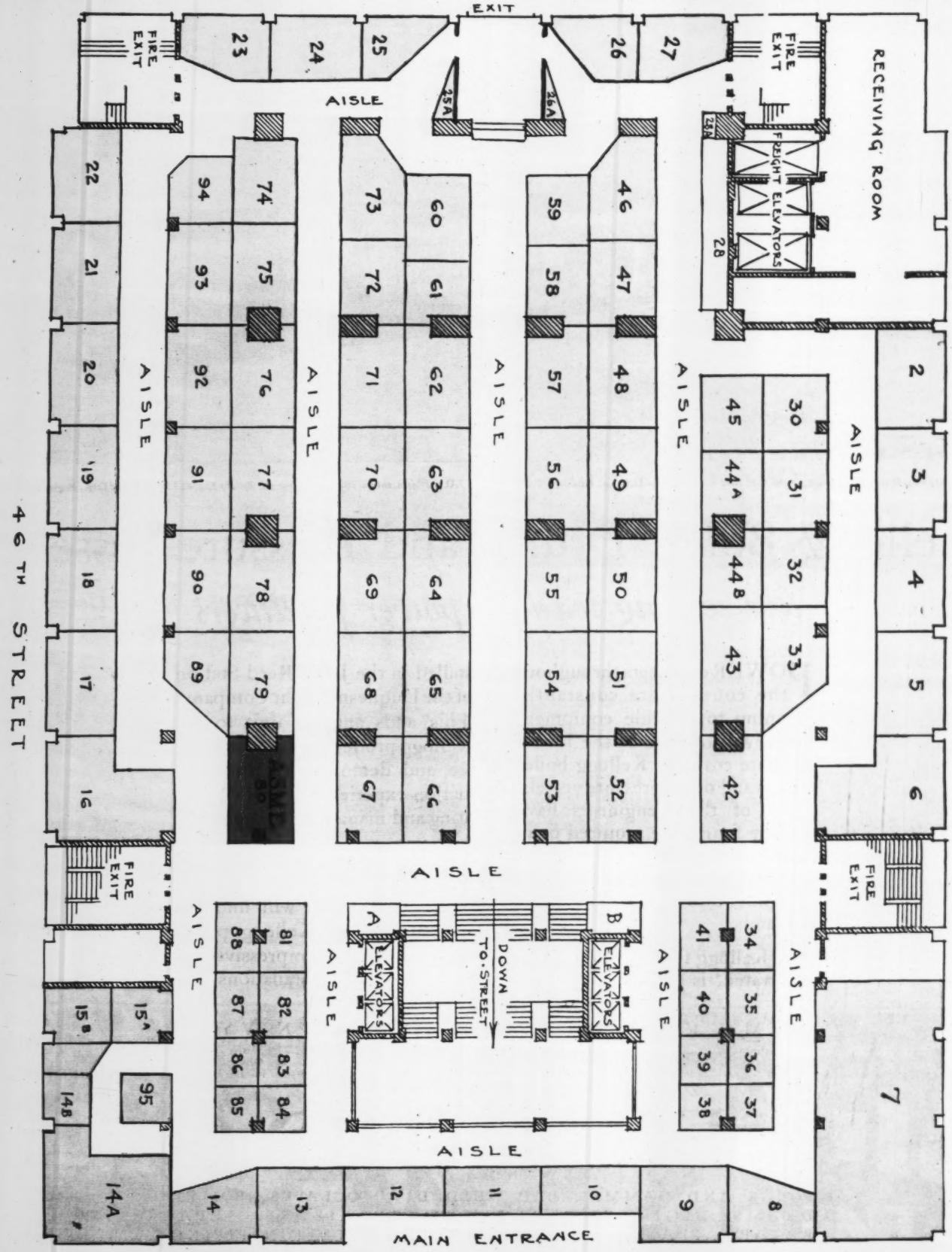
See our data in 1929-30 edition A. S. M. E. Mechanical Catalog

ALL KELLOGG FORGE AND HAMMER LAP WELDED PRODUCTS ARE INSURABLE

FIRST FLOOR BOOTHS NO. 1 to 95

Eighth National Exposition of Power and Mechanical Engineering

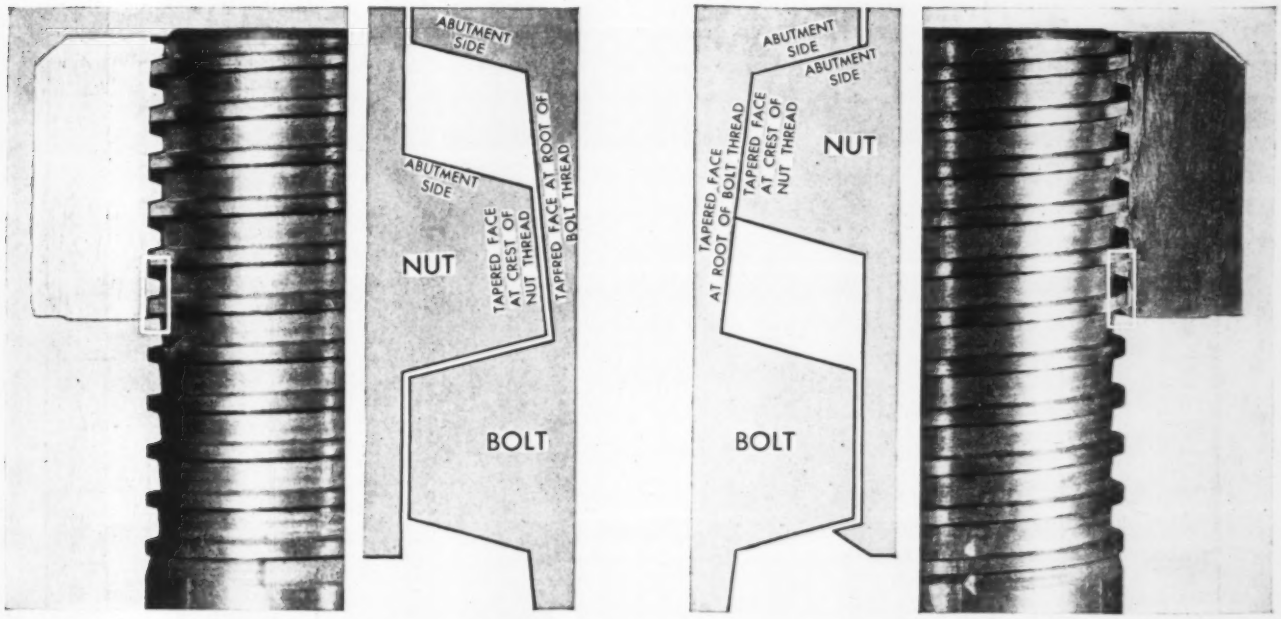
December 2nd to 7th, 1929 — **Grand Central Palace, New York, N. Y.**



See Pages 74-94 for Directory of Exhibitors

See Page 128 for Alphabetical List of Advertisers in this Section

DARDELET



Unlocked **Locked**

A SCREW THREAD WHICH IS SELF-LOCKING AT ANY POINT ALONG THE THREADED LENGTH . . . IS ADJUSTABLE . . . HAS GREAT STRENGTH . . . AND CAN BE USED REPEATEDLY. VIBRATION ONLY LOCKS IT TIGHTER . . . A TOOL ALONE CAN LOOSEN IT.

Samples and information sent on request

DARDELET THREADLOCK CORPORATION

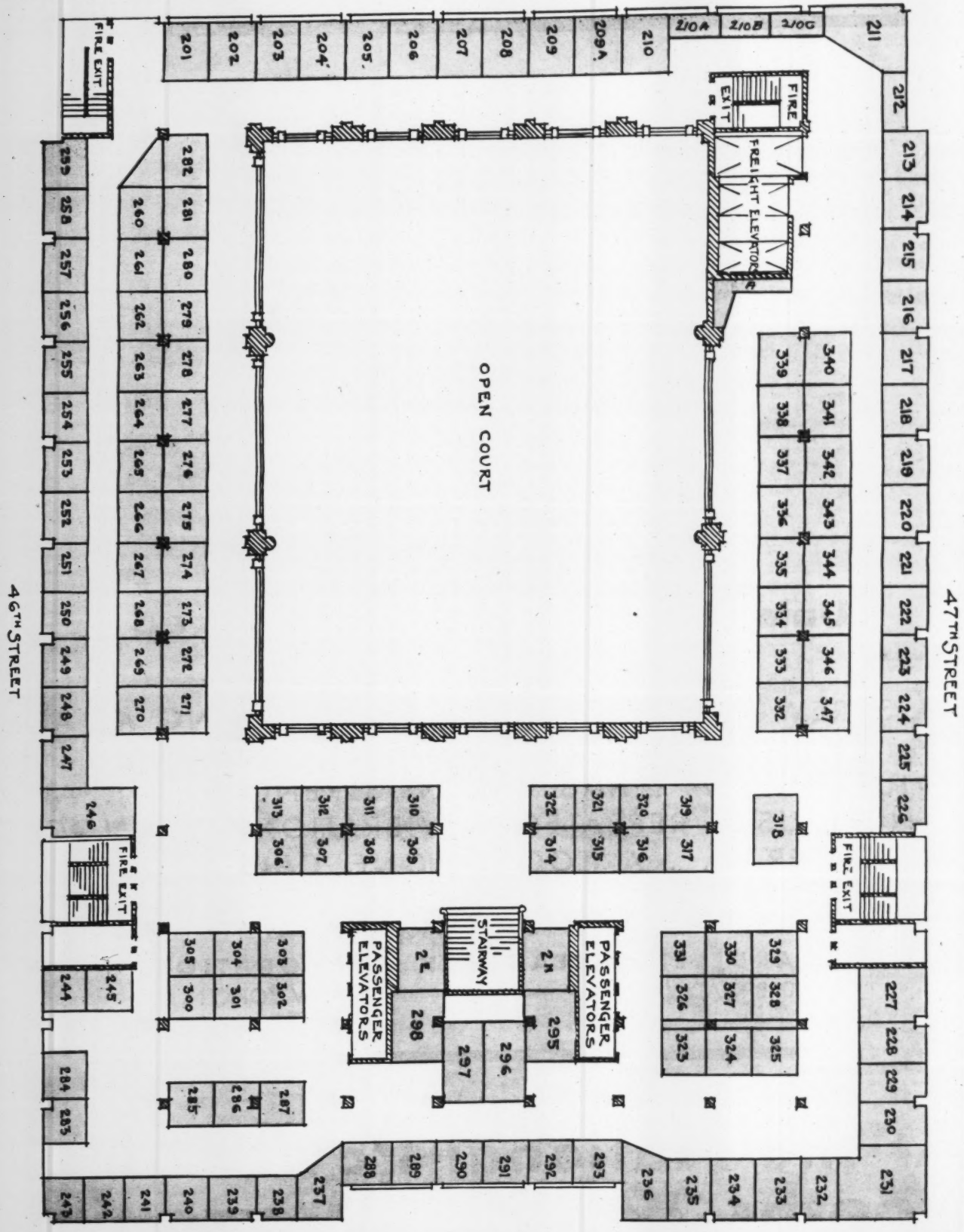
120 BROADWAY NEW YORK, N. Y.

At the National Power Show
Booths 296-297 Mezzanine

SECOND FLOOR BOOTHS NO. 200 to 348

Eighth National Exposition of Power and Mechanical Engineering

December 2nd to 7th, 1929 **Grand Central Palace, New York, N. Y.**



See Pages 74-94 for Directory of Exhibitors

See Page 128 for Alphabetical List of Advertisers in this Section

Why you should buy Edward Valves, here are two good reasons

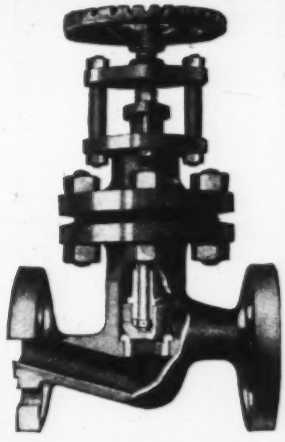
1. You can safely standardize on Edward Valves because their dependability and low maintenance cost have been proved in many notable power plant installations.

2. And due to the tests imposed upon all Edward Valves, every one you buy will measure up to the Edward standard of performance.

Machine shop is equipped throughout with the latest developments for rapid and accurate production.

EDWARD
VALVE & MANUFACTURING CO.
EAST CHICAGO - - - INDIANA
REPRESENTATIVES IN ALL PRINCIPAL CITIES

THEY GUARD EDWARD QUALITY
Ivan Mattson and Carl Bales, screw machine department inspectors, both with Edward seven years.



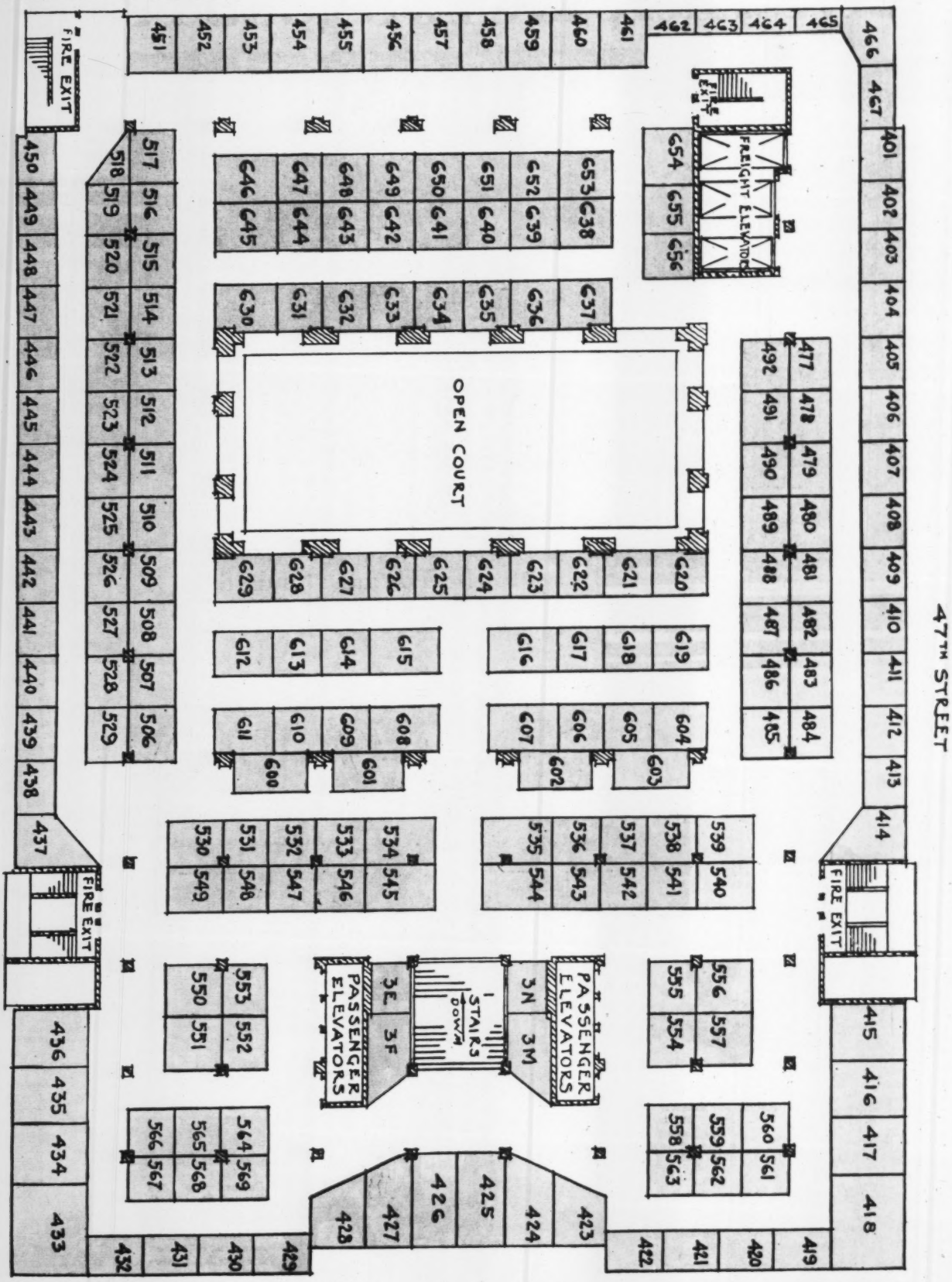
Edward No. 828 Forged Steel O. S. & Y. Globe valve 400-600 lb. W. S. P., one of the many new types Edward has designed.

GLOBE AND ANGLE — NON-RETURN — BLOW-OFF — FEED LINE — CHECK — ATMOSPHERIC RELIEF, ETC.

THIRD FLOOR BOOTHS NO. 500 to 656

Eighth National Exposition of Power and Mechanical Engineering

December 2nd to 7th, 1929 — Grand Central Palace, New York, N. Y.



See Pages 74-94 for Directory of Exhibitors

See Page 128 for Alphabetical List of Advertisers in this Section

NEW YORK POWER SHOW

An Operating Exhibit of Interest to All Users of Belt Drives

A LENIX Drive will be installed on a high speed blower.

Come in and study this Short Center Drive that actually protects the belt—our engineers will explain why.

Come in and study this Short Center Drive that can successfully handle very high-speed transmission—our engineers will explain why.

Come in and study this Short Center Drive that permits the use of higher speed, less expensive motors or generators and two bearing units (up to about 300 H.P. or 225 K.V.A.) —our engineers will explain why.

Come in and study this Short Center Drive that permits the drive to extend in any direction and yet be a 98.8 % efficient drive—our engineers will explain why.

These and other advantages of the LENIX Drive take it so far out of the class of "belt idlers" that there is no comparison. The LENIX is a modern aid to belt drives in nine distinct ways. Ask about them when you visit our booth.

F. L. SMIDTH & COMPANY

Incorporated 1895 Engineers

225 Broadway, New York, N. Y.

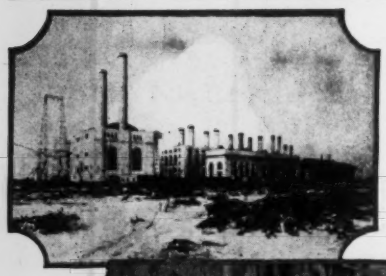
Modern as Long as Driving by a Belt is Modern

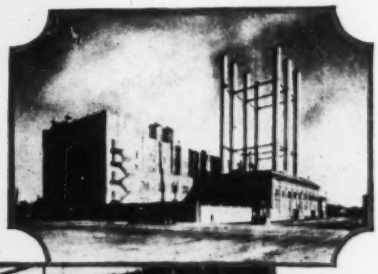
The LENIX Drive

Reg. U. S. Pat. Off.

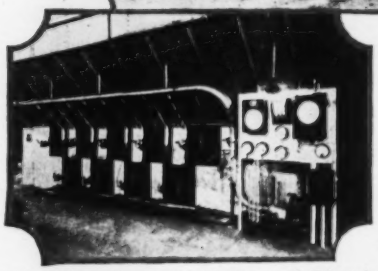
BOOTH 46—NEW YORK POWER SHOW—DEC. 2 to 7

PEABODY



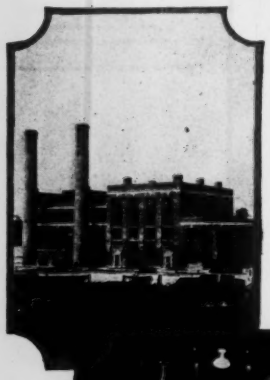


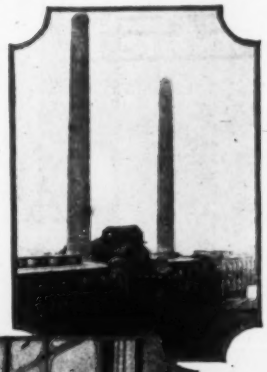
Southern California Edison Co. Stations Nos. 1, 2 and 3, Long Beach, Calif.

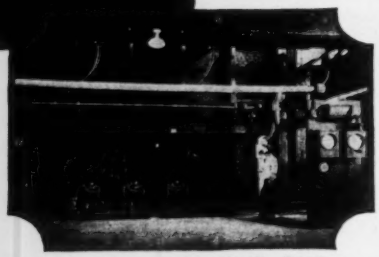


San Diego Consolidated Gas and Electric Co., San Diego, Calif.

Modern Power Plants have demonstrated their preference for PEABODY Burners whether the fuel is crude oil, distillates, residuum, natural gas or pulverized coal, coke or a combination of any or all of these fuels. Illustrations show a few of the many typical installations of Peabody Burners. In many cases they have re-ordered as often as four and five times for new units and new stations. The reasons are manifold, outstanding among them are the following:

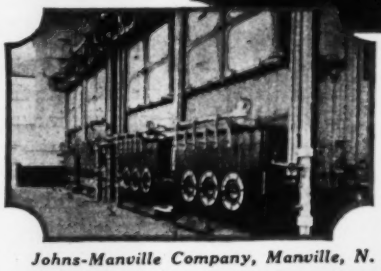




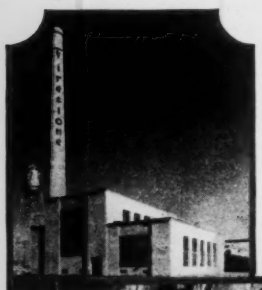


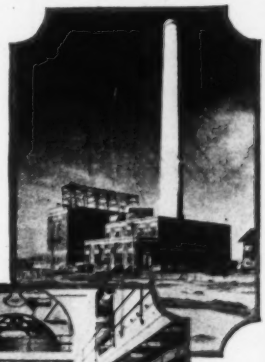
Florida Power Corporation Inglis Station, Inglis, Fla.

- Maximum efficiency
- Minimum maintenance
- Maximum flame control
- Uninterrupted operation
- Positive results
- Wide capacity range

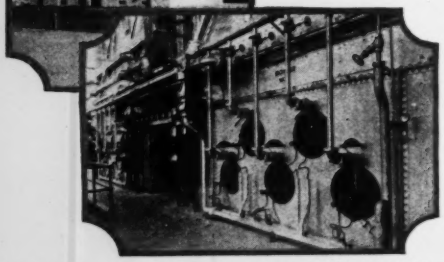


Johns-Manville Company, Manville, N. J.





Sponsored by an organization of engineers who have long been associated with the problem of meeting the requirements of power plants. Pioneers in the advanced burning of oils, gas and pulverized fuel who have led the way to new and better results. Consult them about your requirements.

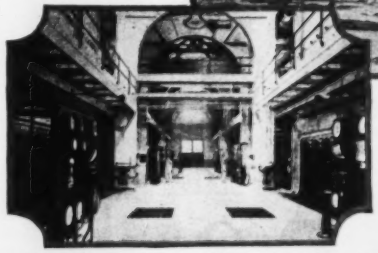


Firestone Tire & Rubber Co., Firestone, Calif.

See our exhibit at
Booth 46
New York Power Show

Order your new Peabody Bulletins by Number

Wide Range Oil Burners	No. 106
Combined Gas & Oil Burners	No. 203
Pulverized Fuel Burners	No. 302
Burners for Oil Stills	No. 501



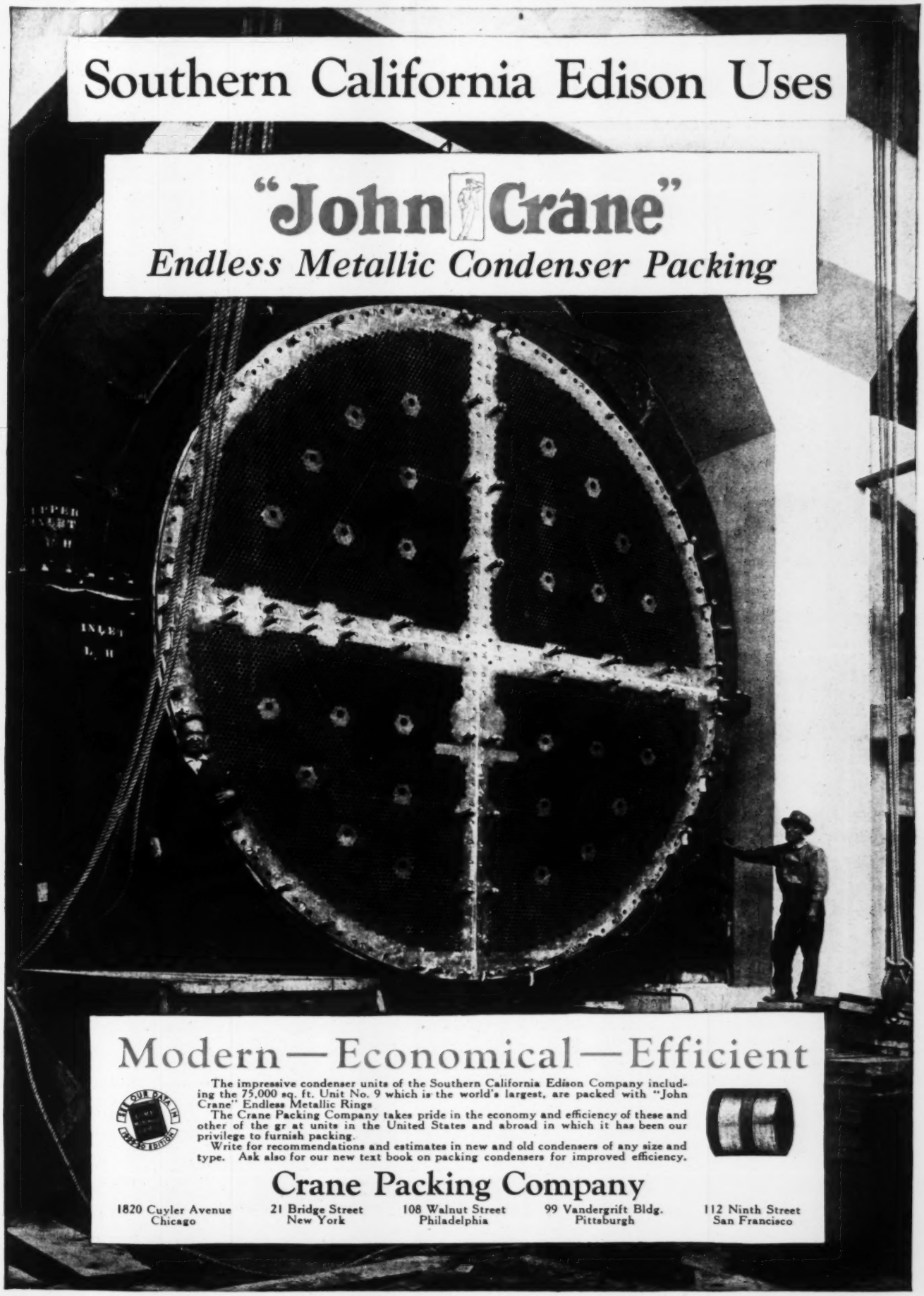
Los Angeles Gas and Electric Corporation Seal Beach Power Station, Seal Beach, Calif.

PEABODY ENGINEERING CORPORATION, 114 EAST 42nd STREET, NEW YORK

Southern California Edison Uses

"John Crane"

Endless Metallic Condenser Packing



Modern—Economical—Efficient

The impressive condenser units of the Southern California Edison Company including the 75,000 sq. ft. Unit No. 9 which is the world's largest, are packed with "John Crane" Endless Metallic Rings

The Crane Packing Company takes pride in the economy and efficiency of these and other of the gr at units in the United States and abroad in which it has been our privilege to furnish packing.

Write for recommendations and estimates in new and old condensers of any size and type. Ask also for our new text book on packing condensers for improved efficiency.

Crane Packing Company

1820 Cuyler Avenue Chicago | 21 Bridge Street New York | 108 Walnut Street Philadelphia | 99 Vandergrift Bldg. Pittsburgh | 112 Ninth Street San Francisco

BOOTH 13—NEW YORK POWER SHOW—DEC. 2 to 7

SIX SCIENTIFICALLY RELIABLE SERVICES

During our forty-three active years of service to engineers, Dearborn Methods have followed scientific lines. As research has disclosed possibilities of greater effectiveness and subsequent experience has demonstrated them, they have been adopted and our own standards have mounted higher.

The six Dearborn services which are in use today by engineers are scientifically reliable.

Prevention of Boiler Water Troubles

This is an exact method of correcting the troublesome tendencies in water supplies used in steam boilers. The water supplies are analyzed in the Dearborn Laboratories. Each plant's operating conditions are known. By means of scientific prescription and constant laboratory control, scaling, foaming, pitting and corrosion are eliminated. This service is adjusted to meet conditions as we find them whether raw or treated water or a proportion of condensate are used.

Internal Corrosion

Elimination of corrosion, pitting and "red" water in closed circulating systems has been a serious problem. Dearborn Methods represent the most advanced practice and operate successfully not only in hot and cold water systems, but in those used for brine, for drinking water and water used in industrial processes. This service includes prevention of pitting and corrosion in equipment out of service.

Scale Removal

Deposits of scale in water lines, jackets, condensers, pumps, heaters, meters and other equipment are dissolved and drained out as sludge with Dearborn Special 134. Regardless of the hardness or thickness of the scale, the equipment can be cleaned thoroughly, quickly and at small cost.

NO-OX-ID Rust Preventive

This material, made in a range of desirable consistencies, chemically inhibits rust by quenching the tendency of the surface to corrosion. At the same time it protects the metal with a flexible non-hardening seal. Whether for use in your own plant or on the iron and steel products of your manufacture, know NO-OX-ID. In use by 121 railroads, by refrigerating plants, power plants, automobile manufacturers, on hundreds of miles of pipe line and wherever rust is a problem.

Lubrication

There is a Dearborn oil or grease for every industrial service. In formulating these lubricants, the purpose was perfection. The standard is unvarying under the constant supervision of the Dearborn laboratories. Many remarkable service records have been produced by these lubricants including the world's longest continuous turbine run.

Cleaners

Dearborn Laboratories supply a range of cleaners of graduated degrees of strength and characteristics suitable for various services. One of our cleaners will remove grease spots from concrete.

Investigate!

If you are attending the New York Power Show, visit our booths and discuss your problems with the Dearborn man in attendance. If you are reading this advertisement at home, write us and let us send you literature and suggestions that our experience directs.

DEARBORN CHEMICAL COMPANY

310 S. Michigan Ave., Chicago — 205 E. 42nd St., New York

2454-2464 Dundas St., West, Toronto

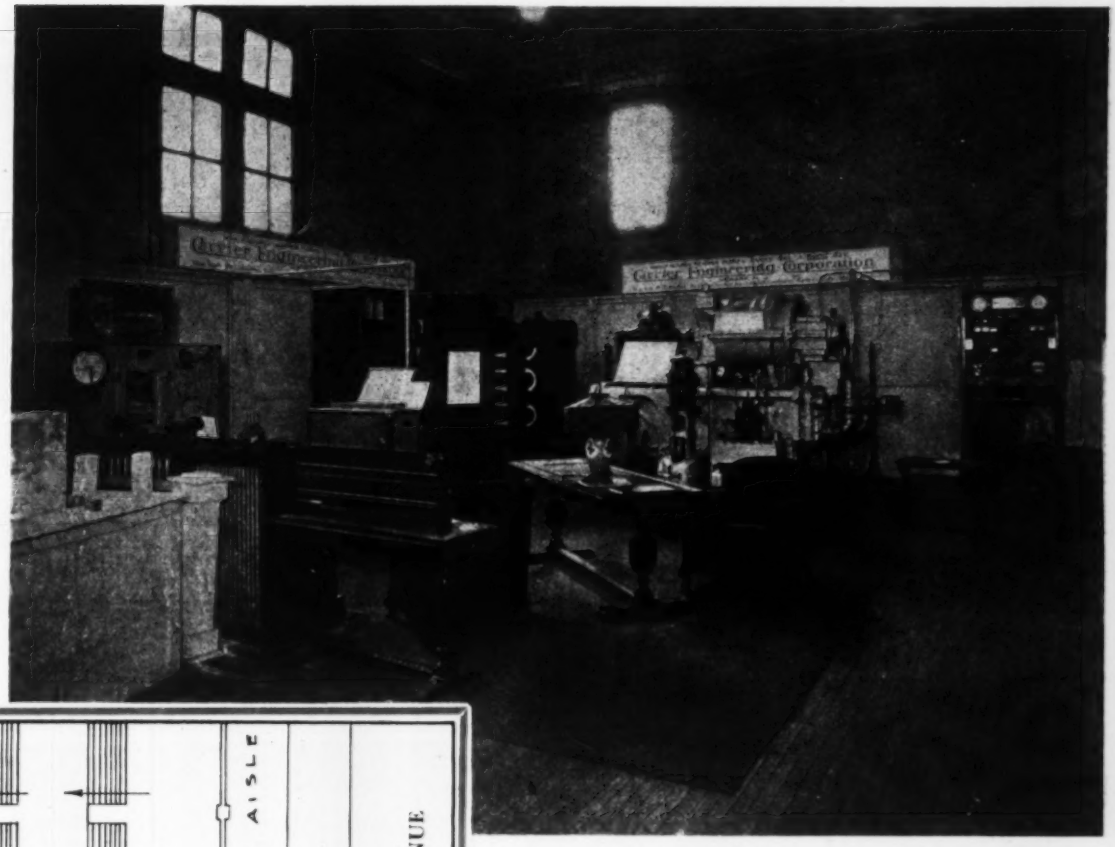
Established 1887

Dearborn

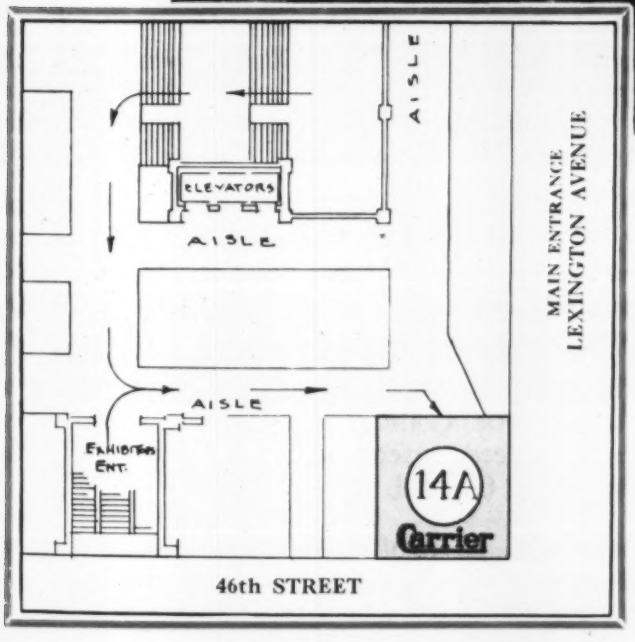
TRADE MARK REGISTERED

SEE THE NEW DEVELOPMENTS IN AIR CONDITIONING EQUIPMENT

. . . BOOTH 14-A



The Carrier Corner Booth 14-A



YOU'LL find us at our usual place at the Power Show, with a display of unusual importance to engineers, to architects, to anyone interested in the planning and construction of private, public and industrial buildings.

Our engineers will be on hand to talk over with you your air conditioning problems. They are experts in the varied fields which we serve and are capable of discussing intelligently the air conditioning applications to your particular building or industry.

Carrier Engineering Corporation

Offices and Laboratories

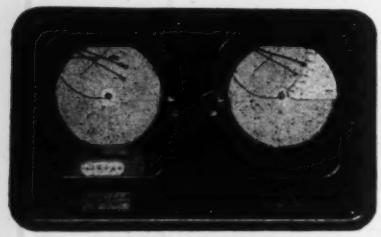
NEWARK, NEW JERSEY

New York Philadelphia Washington Boston Kansas City Chicago Dallas Cleveland Los Angeles Detroit

BOOTH 51—NEW YORK POWER SHOW—DEC. 2 to 7

Holland Station.
Designed and Constructed by W.S. Barstow & Co.

HIGH PRESSURE STATIONS



Bailey Boiler Meter and Feed Water Meter with Temperature Recorders as furnished for Holland Station.
Records—(Right Hand Chart)
Steam Flow
Air Flow
Feed Water Flow
(Left Hand Chart)
Superheated Steam Temperature
Steam Temperature Entering Reheater
Steam Temperature Leaving Reheater
Indicates—Steam Flow
Integrates—Feed Water Flow

Rising as monuments to a Power Age these two new high pressure stations—Holland, owned by the New Jersey Power and Light Company and Deepwater, owned jointly by the American Gas and Electric Company and The United Gas Improvement Company, typify this year's progress in the use of high pressure steam.

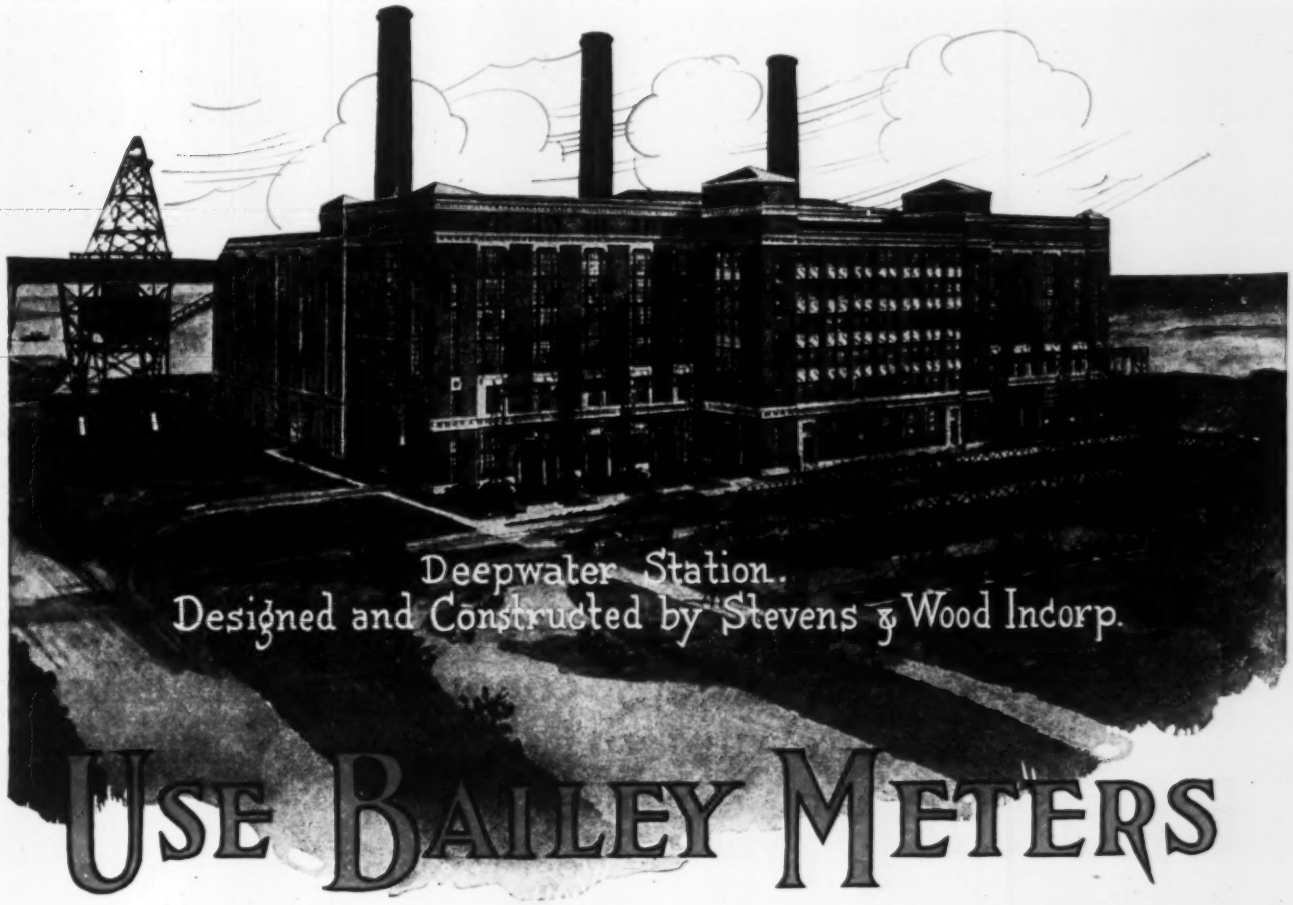
Fully mindful that the increased economies resulting from 1300 lb. steam might be wasted without the proper operating guides, the designers of these stations have insisted on Bailey Metering Equipment. This equipment which is now being installed will record the important factors of boiler operation.

At the Holland Station, boilers will be operated by complete Bailey Automatic Combustion Control. The reheat cycle and the boiler feed water flow at this station will also be regulated by Bailey Control.

See Bailey Metering, Control and Regulating Equipment at the New York Power Show, Booth 51.

BAILEY METERS

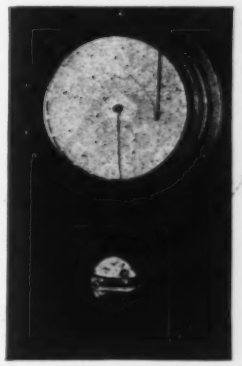
BAILEY METER



USE BAILEY METERS

At the Deepwater Station, meters will be installed for boiler Steam Flow, and Air Flow, turbine steam consumption, and level indication in water storage tanks. The output of this station includes the sale of energy in the form of 180 lb. process steam. The amount of heat energy furnished will be calculated from the readings of Bailey Fluid Meters. These Fluid Meters will be of both the Mechanically and Electrically operated types and will meter steam at 1200 pounds and at 180 pounds pressure.

Cheaper Power by better operation is the spirit of this age. High Pressure Central Stations, Power Process Plants and Industrial Power Plants everywhere are realizing the possibilities of better operation and cheaper power through the use of Bailey Metering, Control and Regulating Equipment.



Bailey Electrically Operated Fluid Meters of this type will measure steam to the 1200 pound pressure turbines at Deepwater Station. They will also be used as a basis for calculation of heat energy furnished by Deepwater Station in the form of 180 lb. process steam.

Bulletins descriptive of Bailey Metering, Control and Regulating Equipment will be furnished on request.

CO. 1026 IVANHOE ROAD CLEVELAND, O.

BAILEY METERS

BOOTH 266—NEW YORK POWER SHOW—DEC. 2 to 7

Vogt Boilers

For All Industries ~

Vogt Boilers are today serving practically every industry requiring steam for power, heating, or process work. They are popular not only because there is a type and size for any condition but because they deliver uninterrupted service continually at the lowest operating expense.

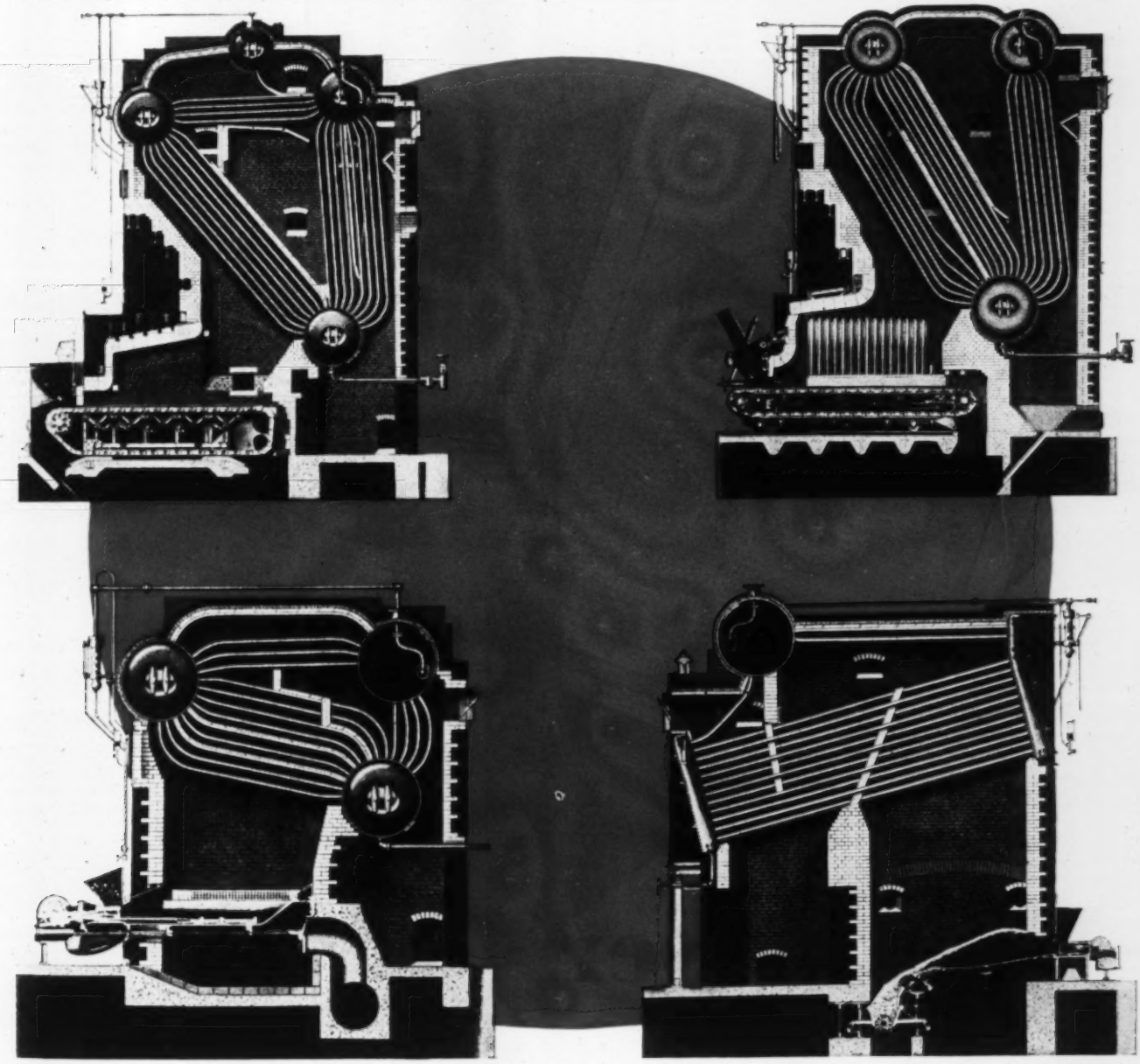
The birdseye below of the Henry Vogt Machine Company plant which covers nineteen acres is a testimony to the facilities and resources of this organization to adequately serve your boiler needs.

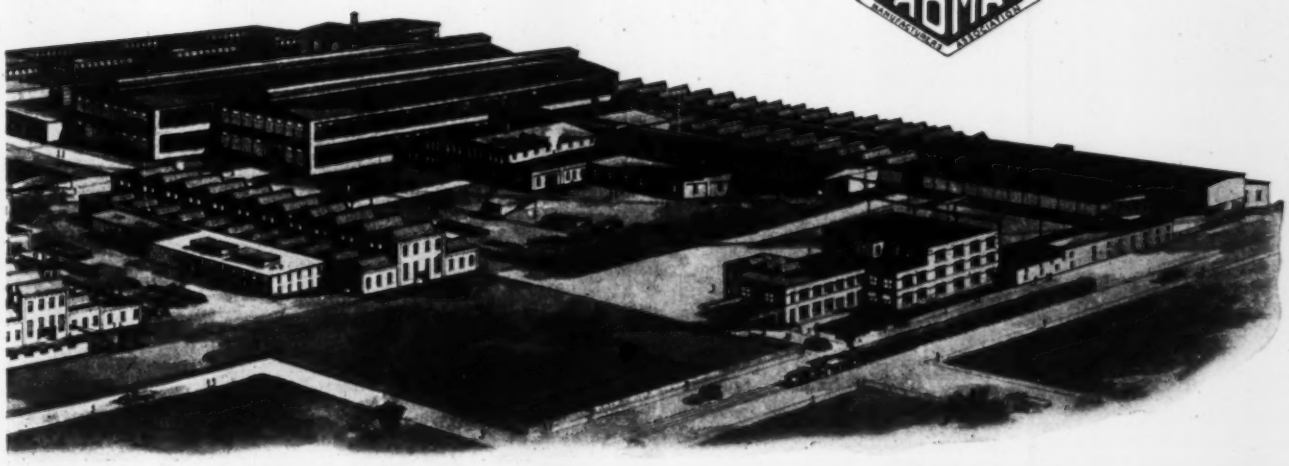
Write for Information

HENRY VOGT MACHINE CO.
(Incorporated)
LOUISVILLE, KY.

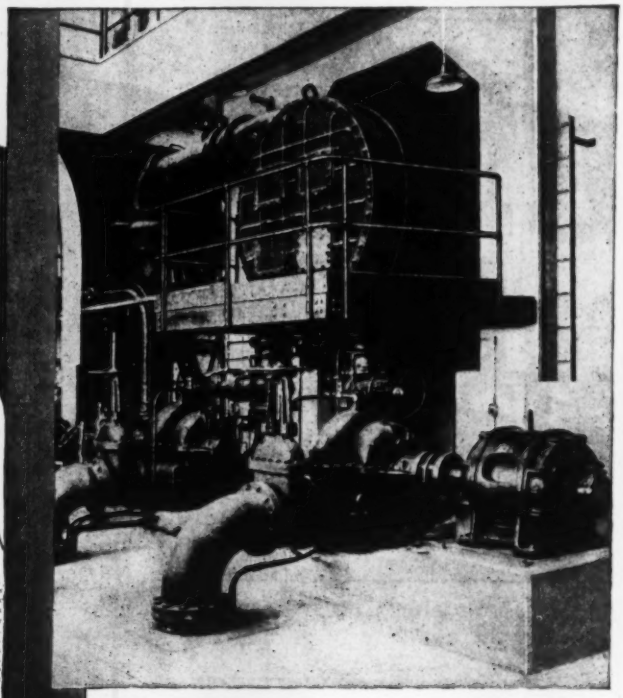
New York Chicago Cleveland Dallas Philadelphia

Manufacturers: of OIL REFINERY EQUIPMENT, DROP FORGED STEEL VALVES AND FITTINGS, WATER TUBE AND HORIZONTAL RETURN TUBULAR BOILERS, ICE MAKING AND REFRIGERATING MACHINERY





BOOTHS 68, 487-88—NEW YORK POWER SHOW—DEC. 2 to 7



Modern Condensers

WESTINGHOUSE ELECTRIC & MFG. COMPANY
SOUTH PHILADELPHIA WORKS PHILADELPHIA, PA
SALES OFFICES AND SERVICE SHOPS IN ALL PRINCIPAL CITIES

Features of Westinghouse small surface condensers:

A LARGE steam dome extending over the tube bank for the full length and width of the shell gives excellent steam distribution which is so necessary for high condenser efficiency.

The liberal tube spacing and short travel of steam through the tube bank reduce friction loss to a minimum.

The tube arrangement is such that a minimum temperature difference is maintained between the incoming steam and the condensate.

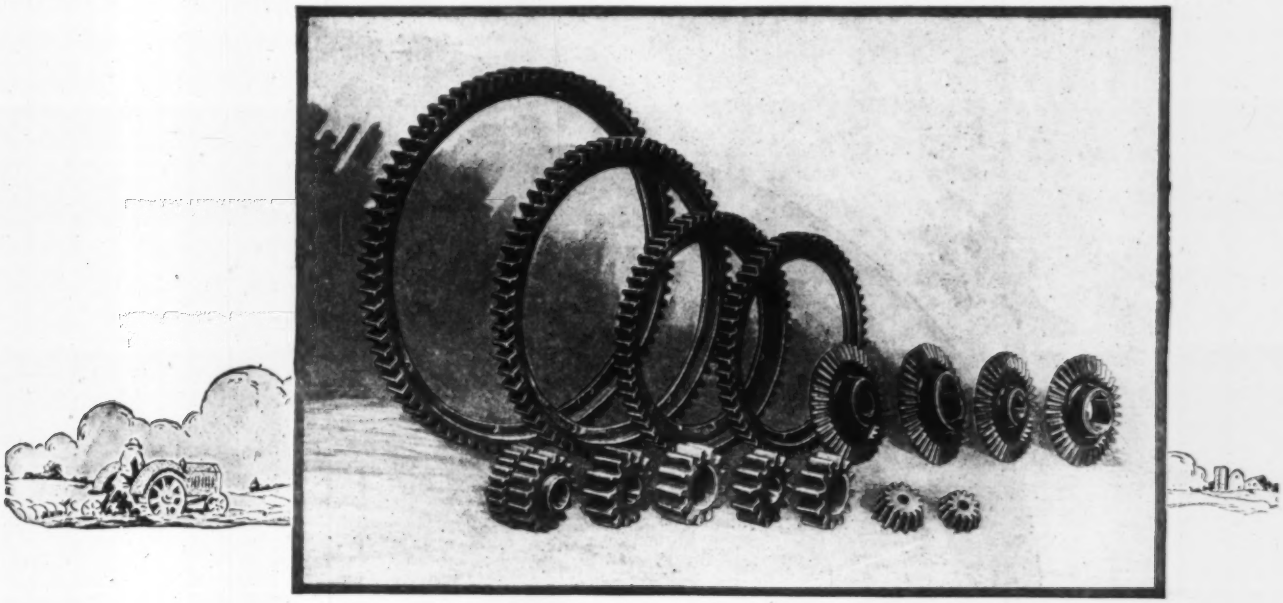
A request to our nearest office will bring you a copy of Leaflet 20424 which describes Westinghouse Small Surface Condensers in detail.

Westinghouse

T 30769

Equipment for power plants includes:

Air Ejectors
Circuit-breakers
Feed Water Heaters
Generators
Generator Air Coolers
Heat Exchangers
Instruments
Insulators
Jet and Barometric Condensers
Meters
Motors
Reduction Gears
Surface Condensers and Auxiliaries
Switchboards
Stokers
Transformers
Turbines



One tractor builder uses these fifteen different sizes and types of Westinghouse-Nuttall heat-treated gears.

It Pays to use Heat-treated Gears

HEAT-TREATING has rapidly become the accepted method of making good gears better. The greatly increased strength, wearing qualities and life which can thus be inexpensively obtained, results in concrete economies. The ultimate cost is considerably less because the extended life means fewer replacements and reduced maintenance expense. Breakdowns are much less frequent. Heat-treating, too, permits the use of smaller gears.

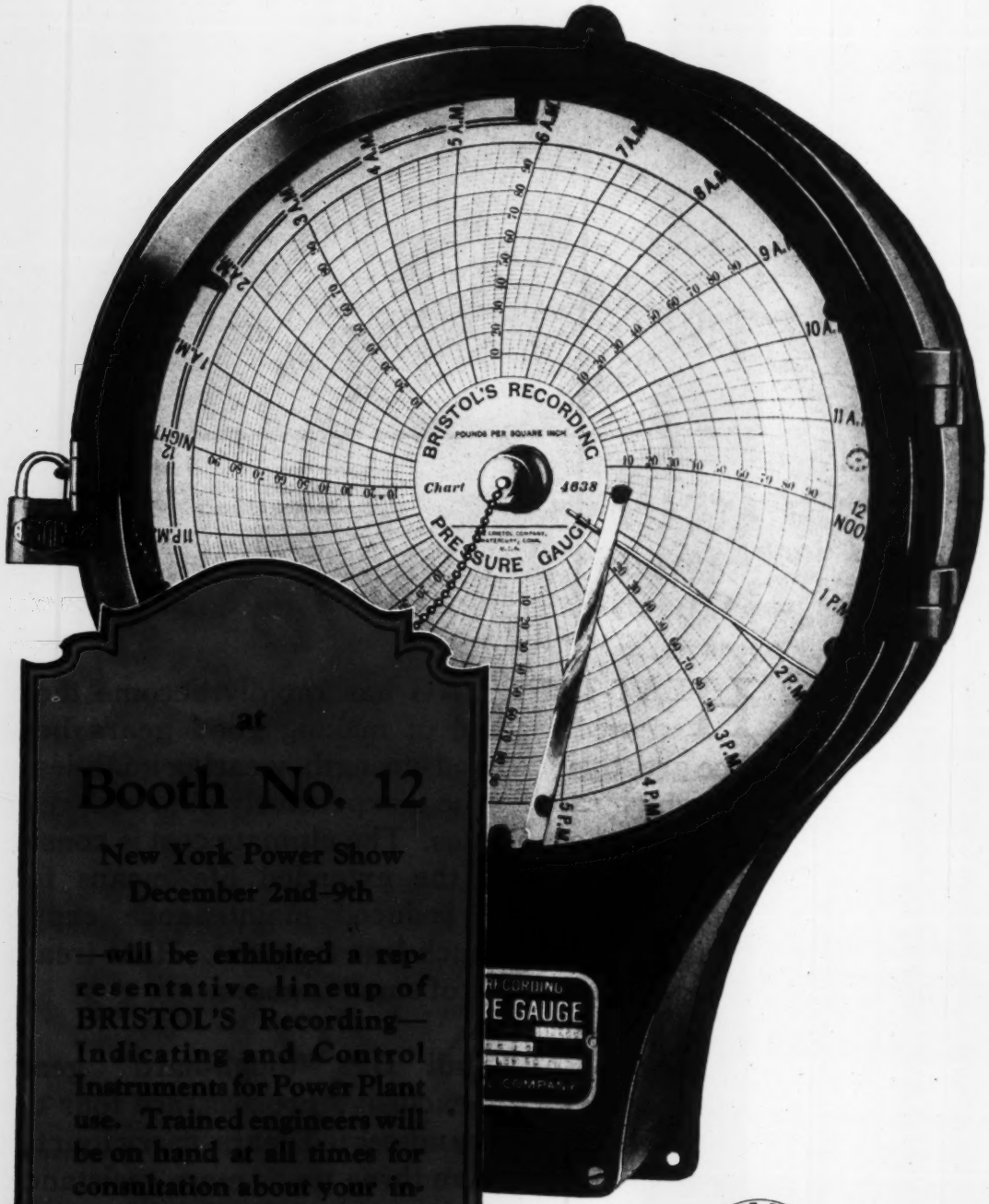
Westinghouse-Nuttall BP "tough-hard" gears—the product of an exclusive process, are four times harder than ordinary untreated gears, carry four times greater load and have three times more resistance to shock impact, yet they cost but slightly more. In identical service, they are guaranteed to have four times longer life.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
NUTTALL WORKS PITTSBURGH, PENNSYLVANIA
SALES OFFICES AND SERVICE SHOPS IN ALL PRINCIPAL CITIES

Westinghouse

T 20858

BOOTH 12—NEW YORK POWER SHOW—DEC. 2 to 7



at

Booth No. 12

New York Power Show
December 2nd–9th

—will be exhibited a representative lineup of BRISTOL'S Recording—Indicating and Control Instruments for Power Plant use. Trained engineers will be on hand at all times for consultation about your instrument problems.

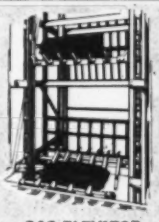
THE BRISTOL COMPANY
WATERBURY, CONN.

SEE OUR DATA IN A.S.M.E. Mechanical Catalog 1929-30 EDITION

BRISTOL'S

Recording—Indicating and Control Instruments

PECK CARRIER


BAG ELEVATOR

SAND AND GRAVEL WASHING PLANT

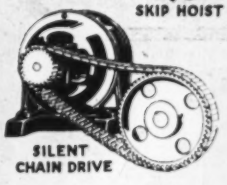
FLIGHT CONVEYOR

FOUNDRY CONVEYOR

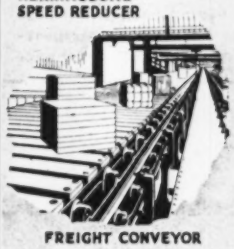
BELT CONVEYOR

ASSEMBLY CONVEYOR

SKIP HOIST


SILENT CHAIN DRIVE

HERRINGBONE SPEED REDUCER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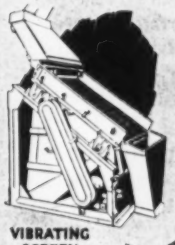
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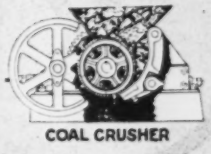
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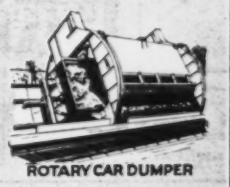
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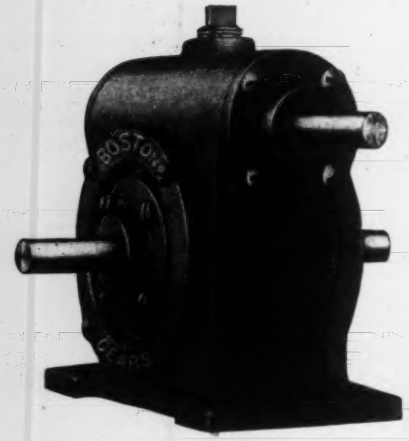

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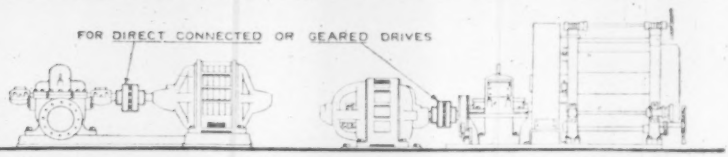

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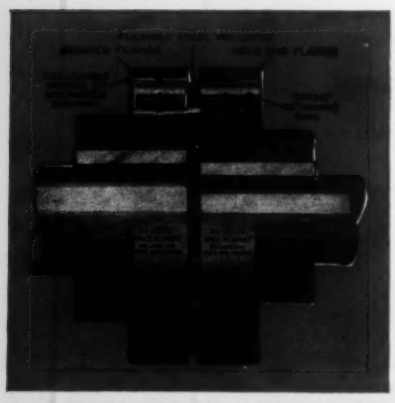

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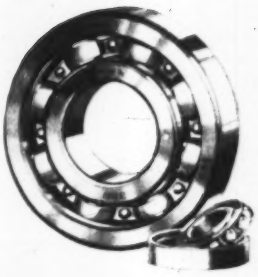

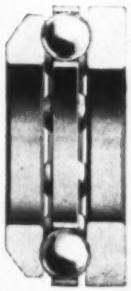

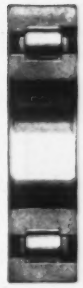

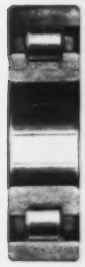

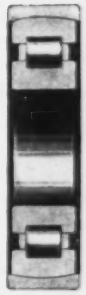

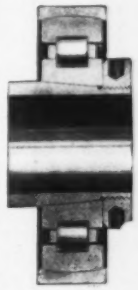

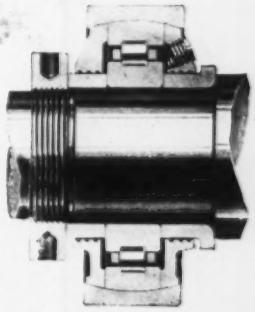

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BOOTHS 68, 487-488—NEW YORK POWER SHOW—DEC. 2 to 7

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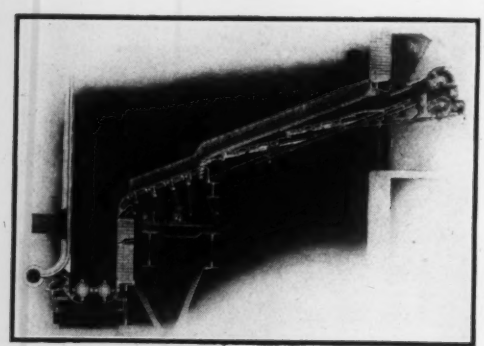

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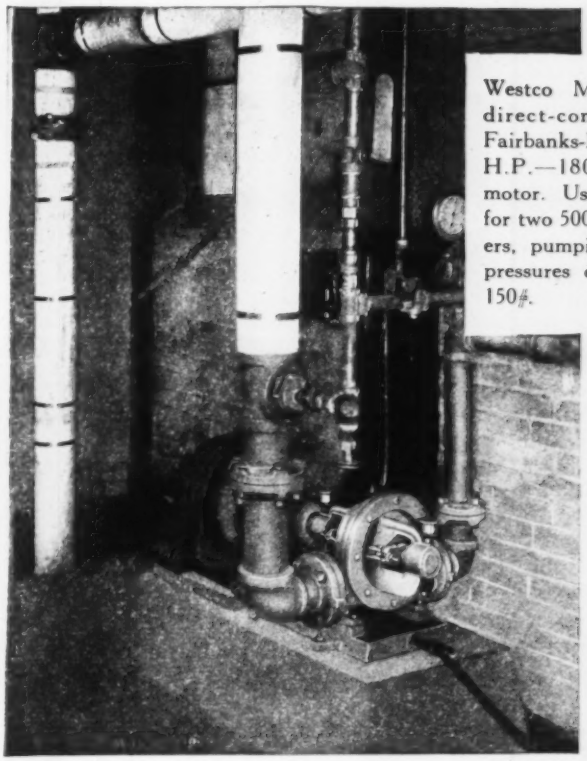

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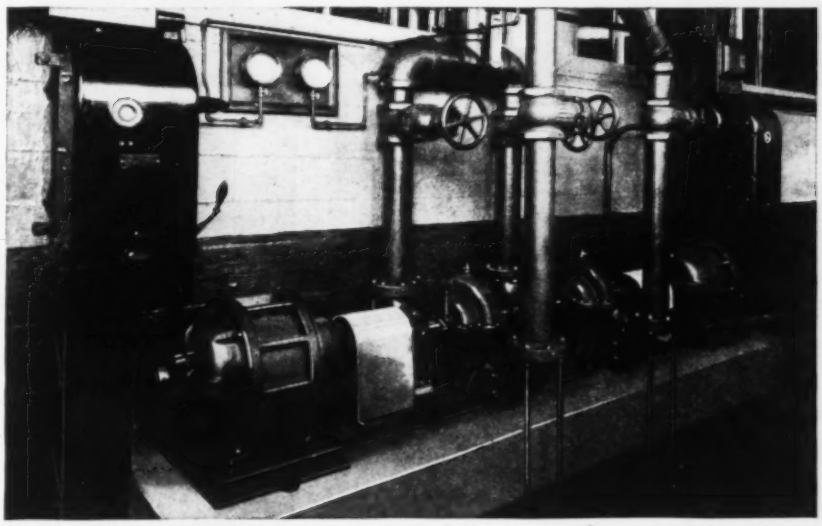

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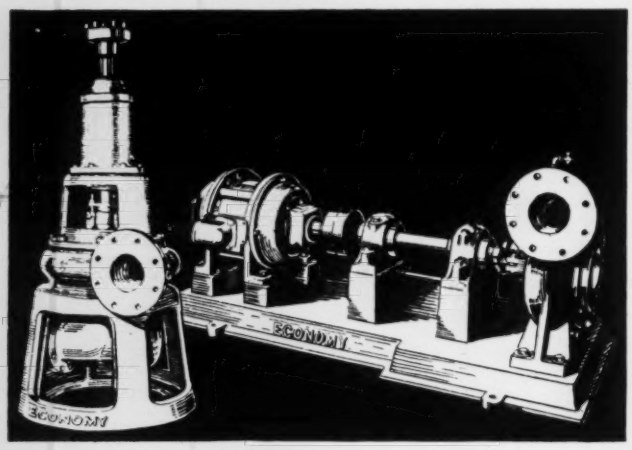

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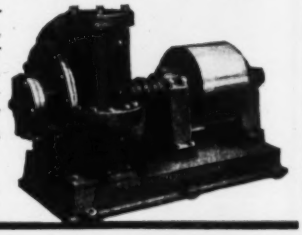

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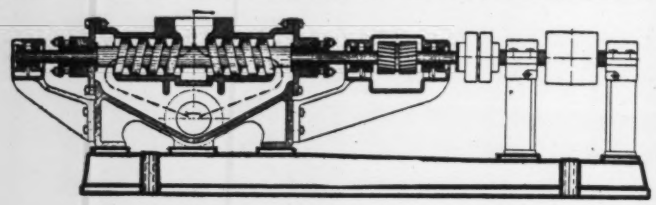

Construction of Quimby molasses pump arranged for belt drive.

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—Built From Practical Experience—

For nearly 40 years the screw pump has been handling molasses in capacities of from 1-4000 G.P.M. at pressures up to 1000 pounds

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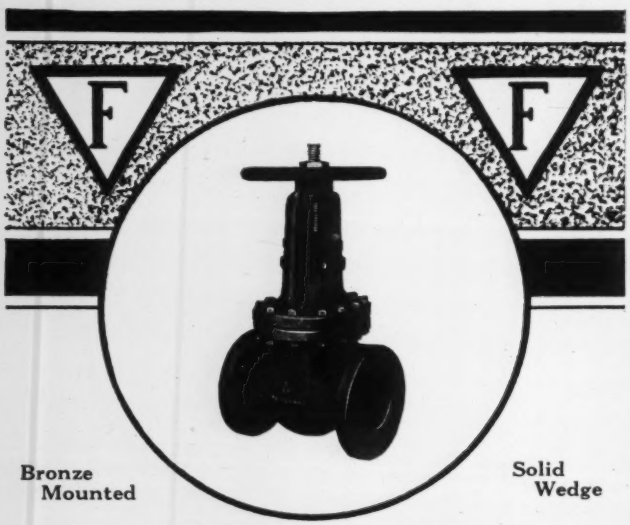

Bronze Mounted

Solid Wedge

FAIRBANKS VALVES

Fig. 0312

Extra Heavy Renewable Iron Body Gate with Bronze Seat Rings

Can be renewed without removing valve from pipe line.

The FAIRBANKS Company

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THE record of the many Kennedy Valve installations that are still in service after twenty, thirty, even forty years of service in central power stations, industrial plants, municipal water supply systems and buildings of every type throughout the country form a safe guide for your own valve selection. And the Kennedy Valves of today are even better than these old-timers, for their design and construction are based on our half-century of experience in meeting the requirements of every conceivable valve service. Sturdy bodies, easily operating mechanisms, accurately machined discs and seats and tough, strong stems are some of the Kennedy Features that assure dependable and economical valve service.

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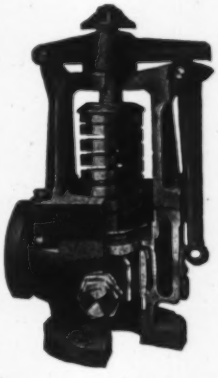

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THEY SAFELY CONTROL HIGHEST PRESSURES AND TEMPERATURES

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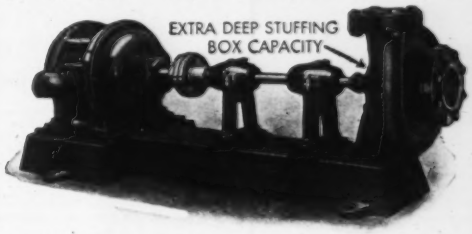

Fig. 603F. Taber Standard Centrifugal Pump.

For Dye Industries where the transfer of caustic solutions necessitates special alloy pump construction, Taber builds them of nickel . . . monel . . . or chrome nickel alloys. And Taber standard centrifugal pumps of iron, semi-steel or bronze are most economical for pumping all kinds of chemical solutions. Where viscous materials must be handled, Taber Rotary Pumps are recommended.

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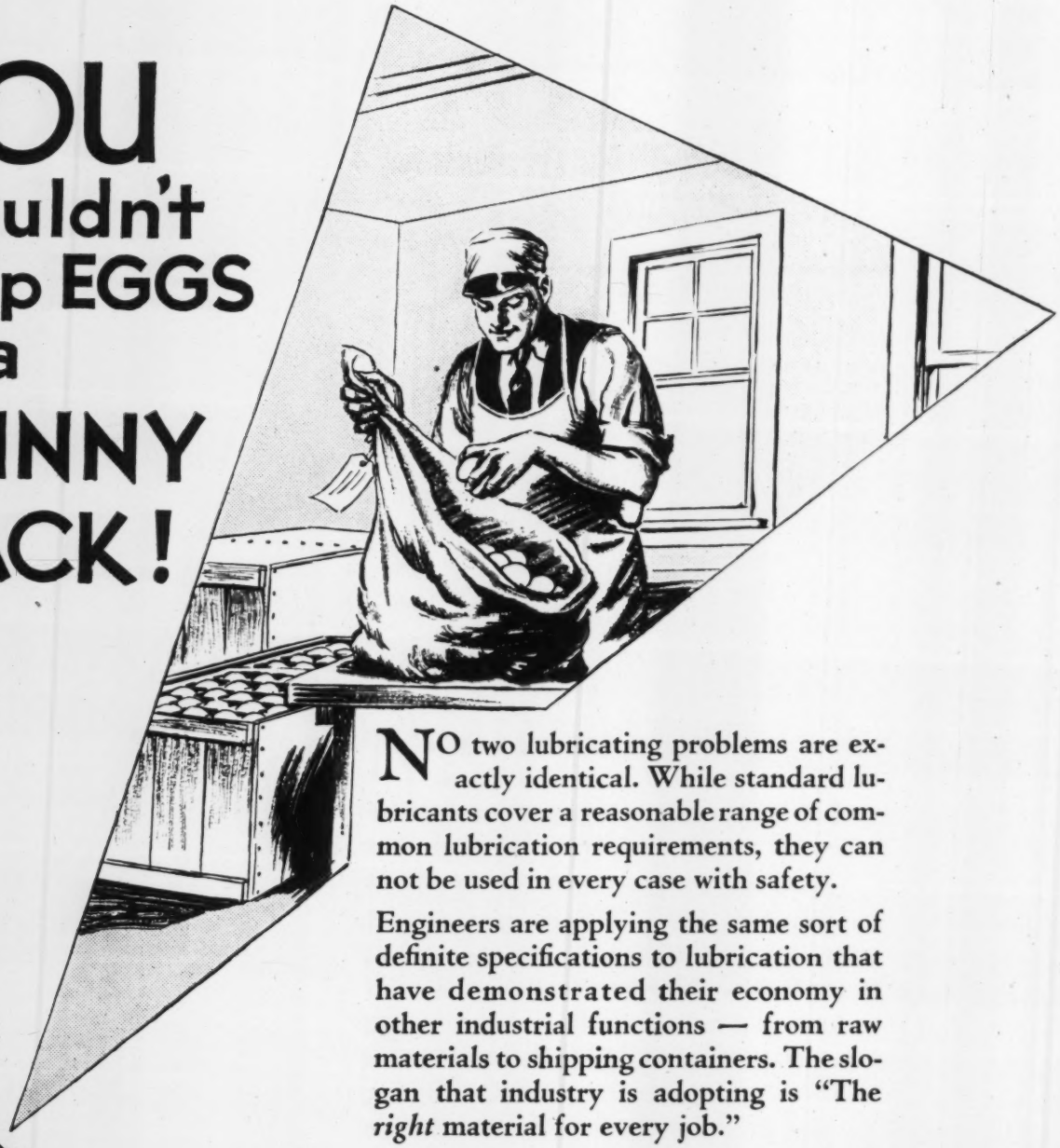

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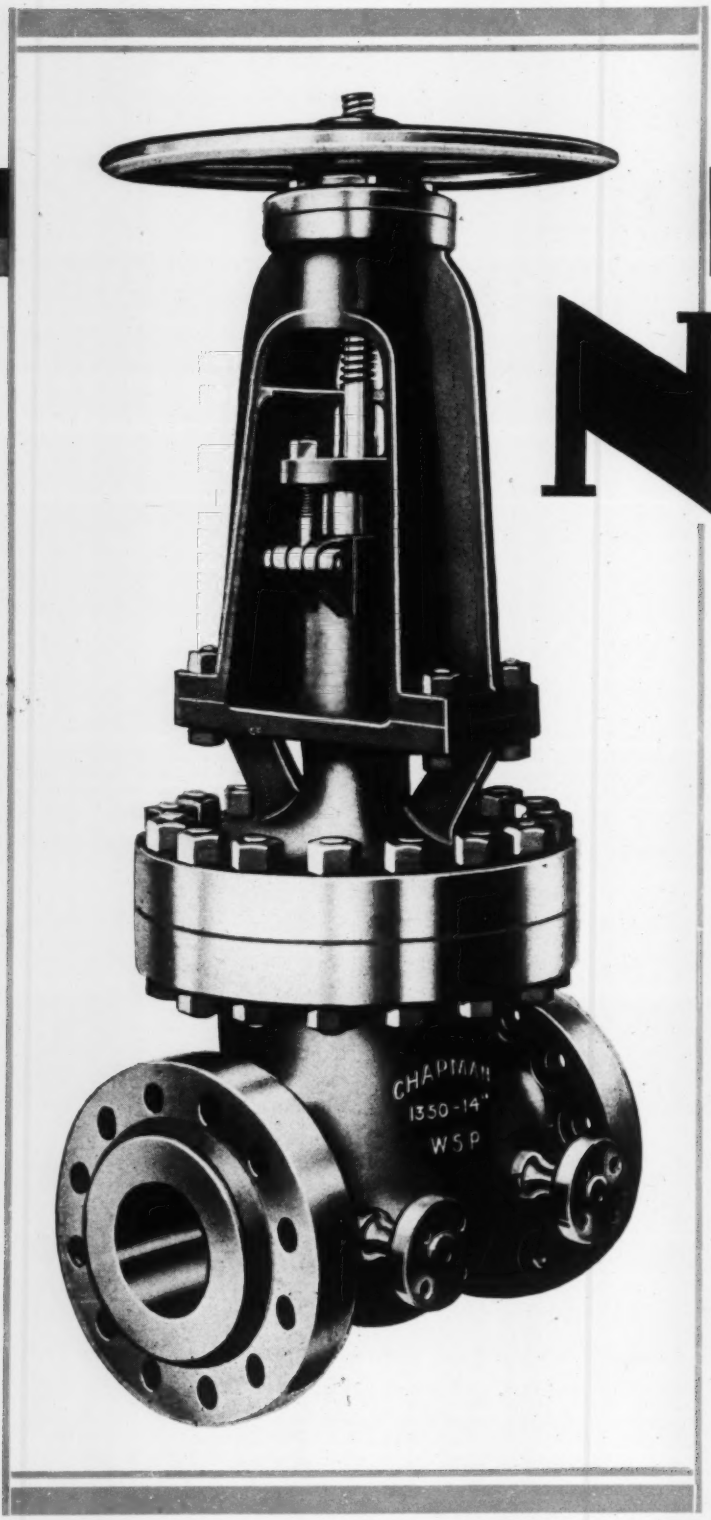

Now in CHAPMAN VALVES exclusively

Valves of CHAPMAN chrome nickel steel, with NITRALLOY mountings, are the last word in high pressure and high temperature equipment. NITRALLOY mountings can now be furnished in CHAPMAN iron and steel body valves.

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Louisville, Kentucky

Smooth-On Coated Corrugated Iron Gaskets

The best for any pressure or temperature for steam, water, oil, air or ammonia

Smooth-On Corrugated Gaskets are iron sheets, with specially rolled concentric corrugations, coated with Smooth-On No. 3, or uncoated, as desired.

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12-29

SMOOTH-ON

MODERN PIPING FOR THE

SEE IT AT THE POWER SHOW BOOTHS 221 and 222

THE power plant, industrial process and oil refinery of today all make demands upon piping—and particularly upon the joints—unknown only a few years ago.

That Midwest has kept pace with these requirements—in fact, that Midwest has anticipated tomorrow's requirements is evident from the few photographs shown here. The Midwest exhibit at the Power Show will tell the story more completely. You are invited to see it.

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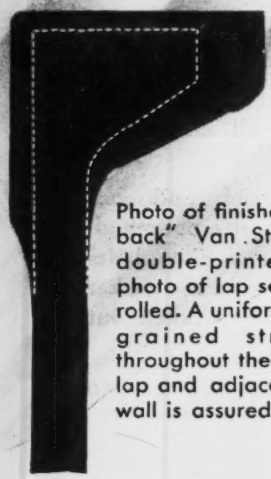
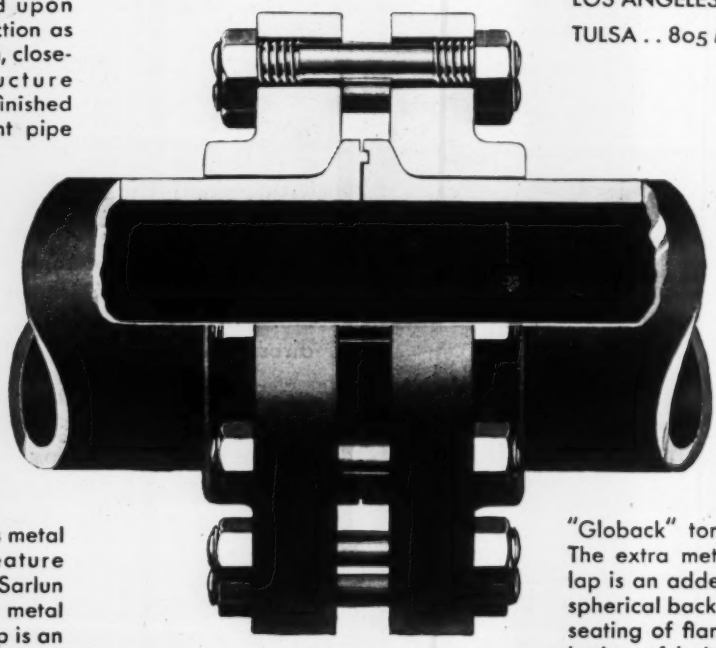
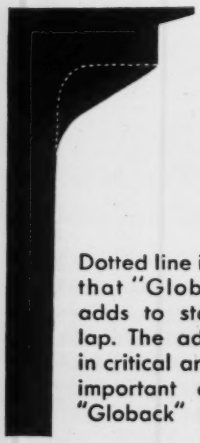


Photo of finished "Globack" Van Stone lap double-printed upon photo of lap section as rolled. A uniform, close-grained structure throughout the finished lap and adjacent pipe wall is assured.



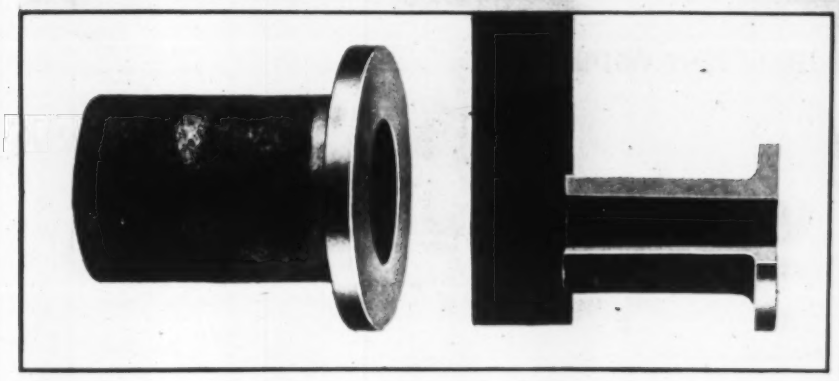


Dotted line indicates metal that "Globack" feature adds to standard Sarlun lap. The additional metal in critical area of lap is an important advantage of "Globack" joints.

"Globack" tongue and groove joint. The extra metal in critical section of lap is an added factor of safety while spherical back faces of laps assure fair seating of flanges and uniform distribution of bolting pressure. Maximum bolting stress is removed from periphery of laps.

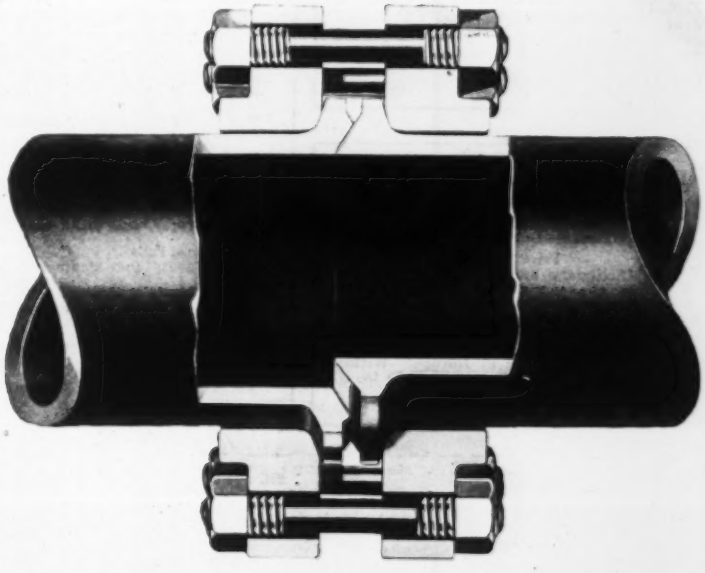
A GREATER MIDWEST

MODERN POWER PLANT



Unretouched photo of section cut from Van Stone lap rolled by Midwest. Note the increased thickness, large radius fillet and square corner.

Midwest has perfected a special process for applying Van Stone laps to small pipe sizes. This photo shows ½" and 1" extra heavy pipe. After machining front and back, lap is full pipe wall thickness, corner is square, and radius of fillet is large.



Midwest Joint requires neither gasket nor field welding. All lap and flange contact surfaces are spherical so piping need not be in accurate alignment and bolting pressure is more uniformly distributed. Laps are heavier than pipe wall thickness.

PIPING SERVICE

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B16a-1928	Cast Iron Flanges and Flanged Fittings for maximum pressures of 125 lbs.	50c
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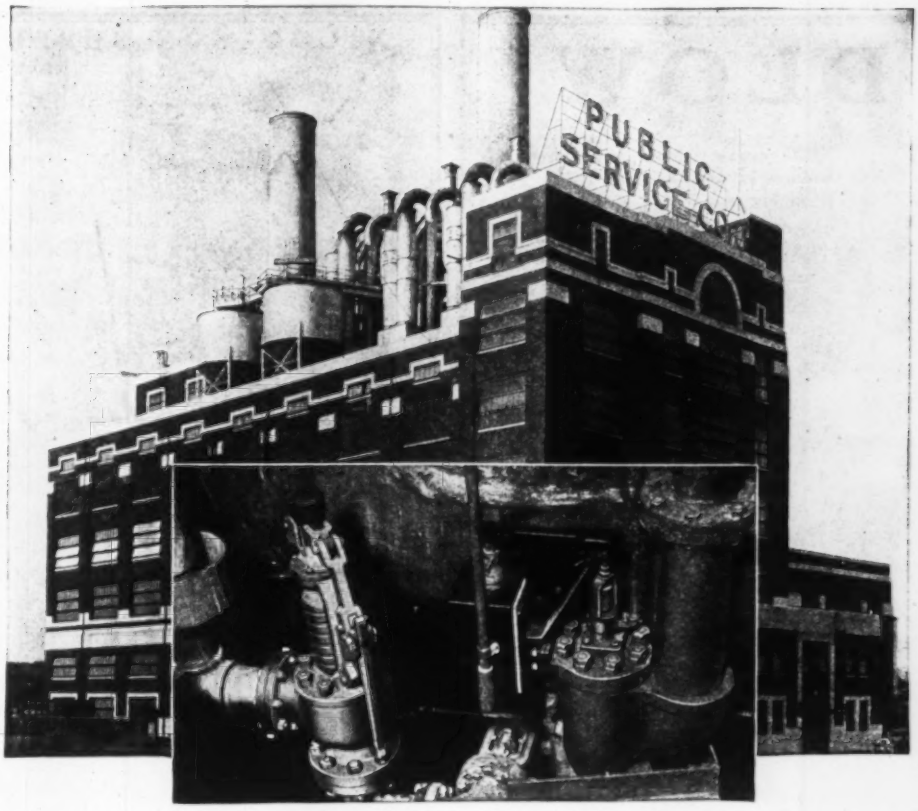

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> *General Supt., Gas & Elec. Depts.*

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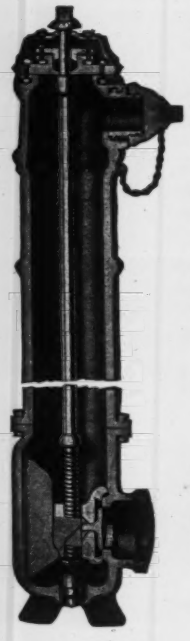

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HYDRANT

8

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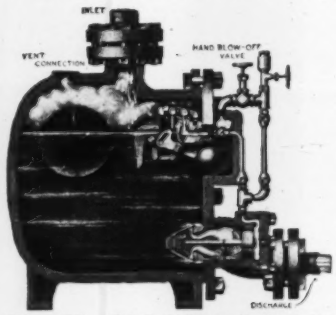
Piston Operated



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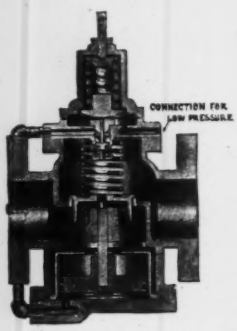

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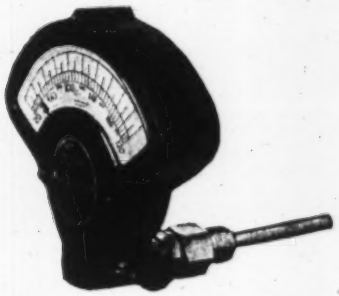

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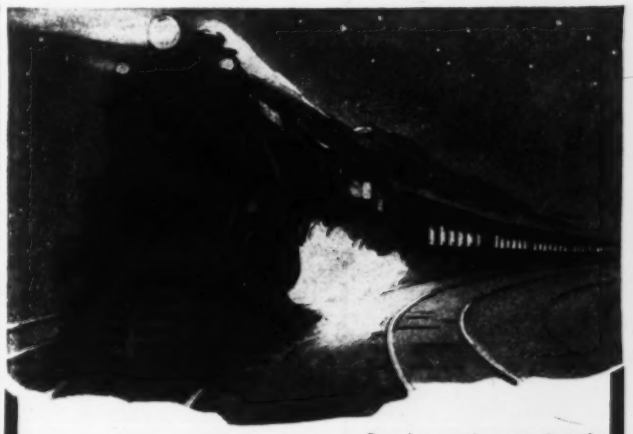

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James D. Cunningham

PRESIDENT

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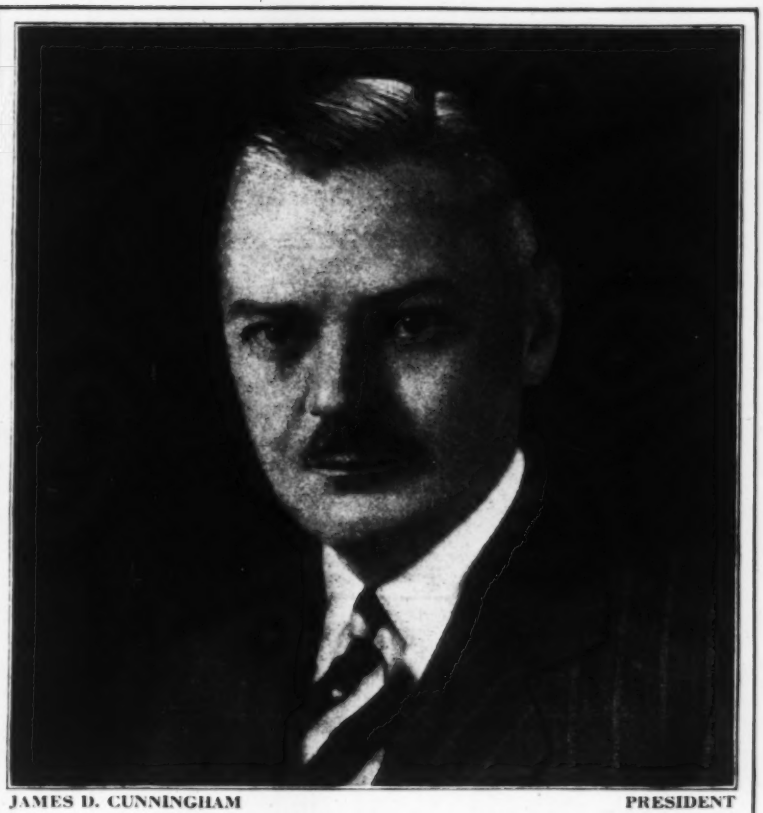

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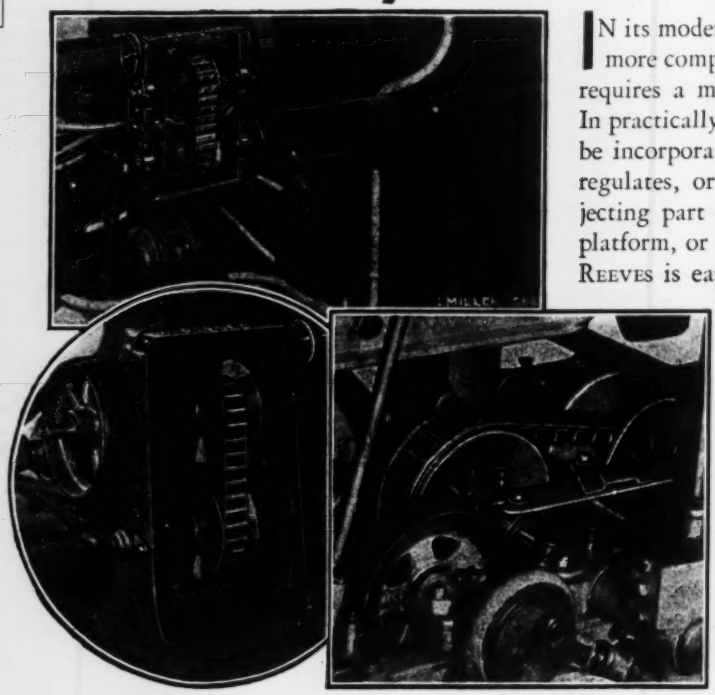
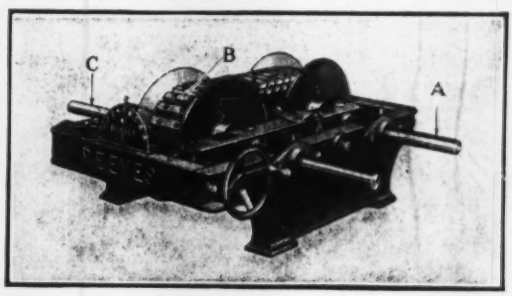


IN its modern design . . . shorter, narrower, more compact . . . the REEVES Transmission requires a minimum amount of floor space. In practically every installation, it can either be incorporated as a part of the machine it regulates, or it can be placed under a projecting part of the machine, mounted on a platform, or suspended from the ceiling. The REEVES is easy to install and takes up very little additional space beyond that already required by the machine it drives.

Above left: Showing the REEVES Transmission compactly mounted right on the frame of a Norton Grinder. *In circle:* Vertical type of REEVES closely installed at the driving end of a Swift Electric Welder. *Lower right:* Internal parts of REEVES built as a standard unit right into a Harton Cake Machine.

POSITIVE
in transmitting power

WITH the REEVES Transmission, any machine can be regulated instantly to run at any desired speed between predetermined limits of fast and slow. It will maintain any one set speed with *positive* accuracy . . . (A) shows the power input shaft which is driven at a constant speed . . . (B) shows the V-belt which *cannot slip* in the V-shaped throat formed by the cone-faced discs . . . (C) shows the power output shaft which remains constant at any one set speed, but which can be regulated, at the will of the operator, to any desired speed.



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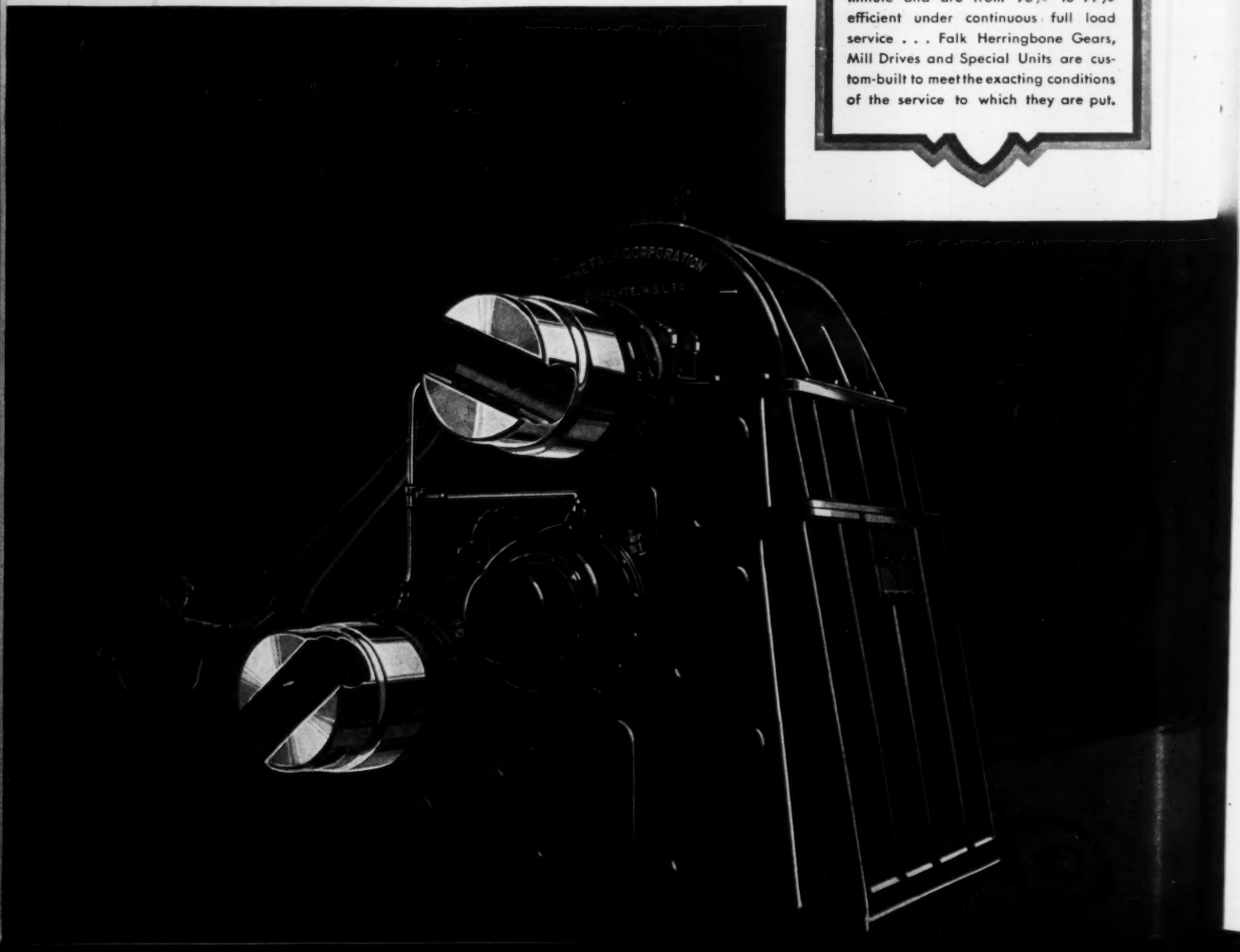

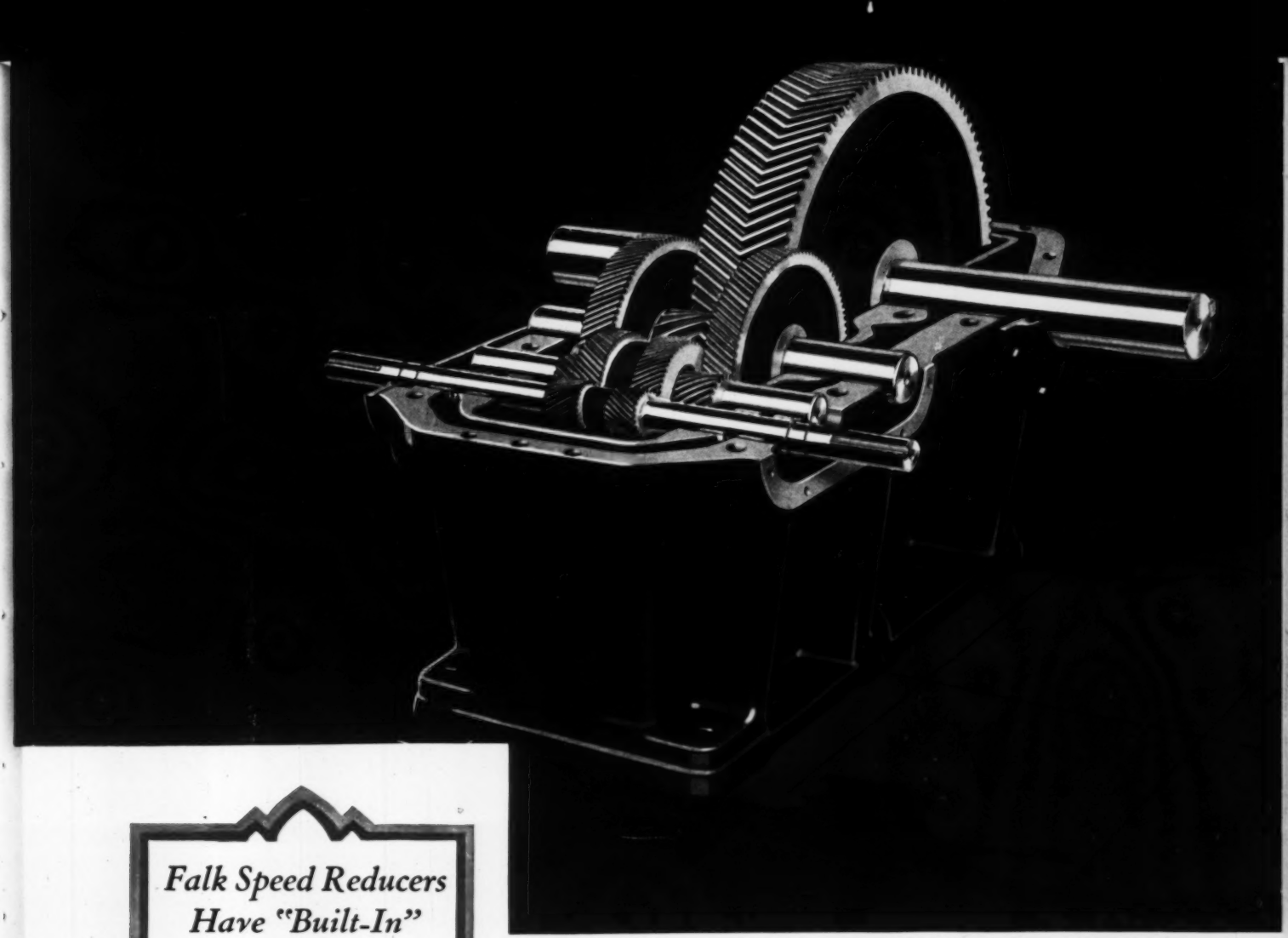

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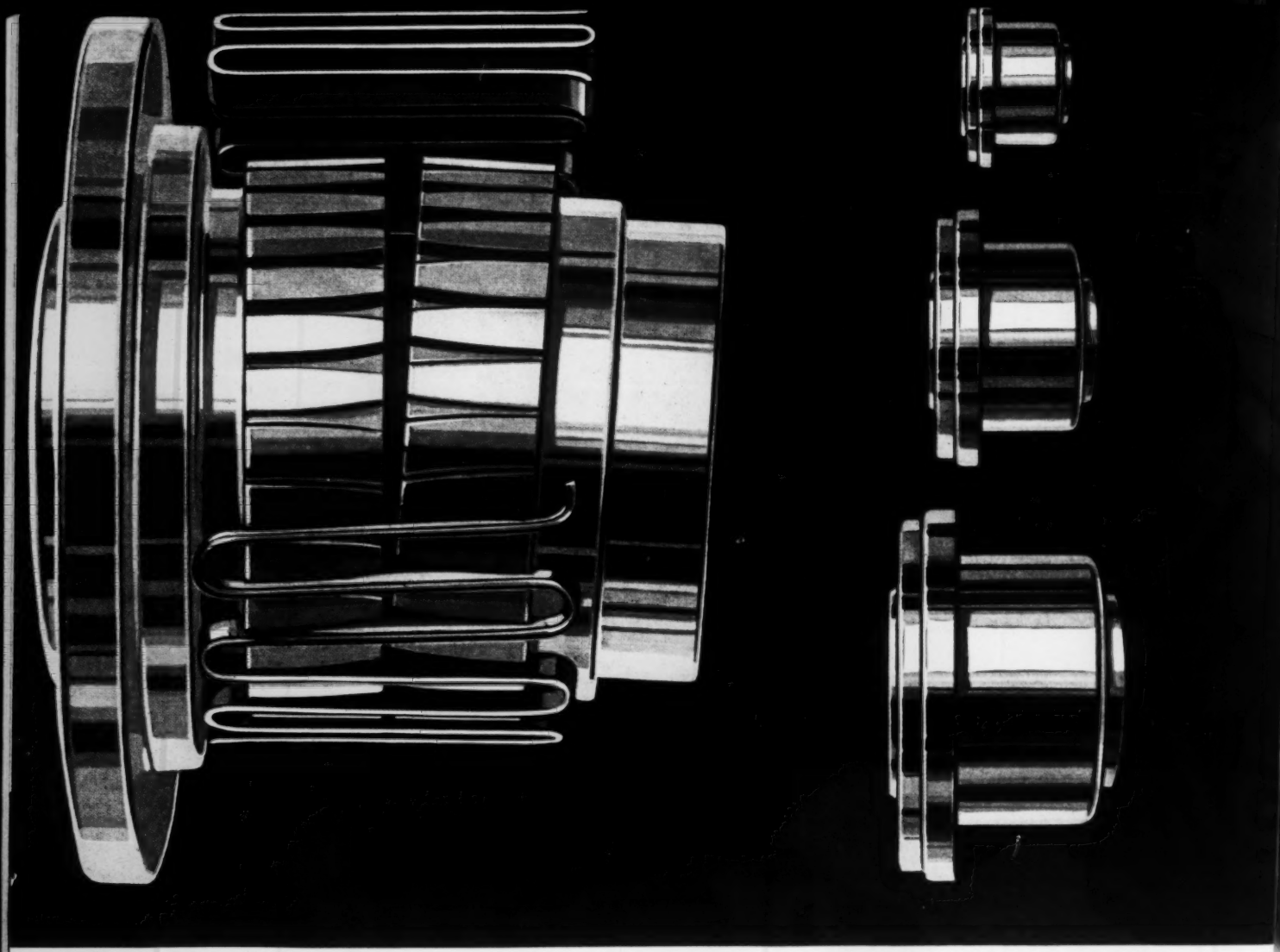

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How? Fast answered that question. As the diagram below shows, two spur gears are in complete and continuous mesh with the internal gears of a floating sleeve. The sleeve takes a neutral position, the error in misalignment is taken up between the lubricated faces of the gear teeth, and all necessity for flexible materials is eliminated.

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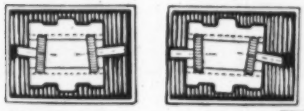
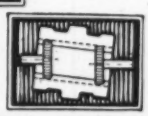
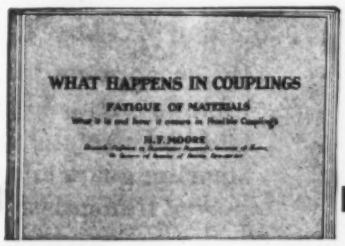
The coupling without flexible bushings, pins, springs, discs, grids or any other flexible materials.



Two spur gears, meshed with the internal gears of a floating sleeve. Coupling revolves as one unit, misalignment being taken up between the lubricated teeth.





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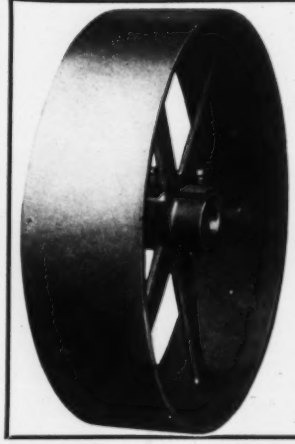

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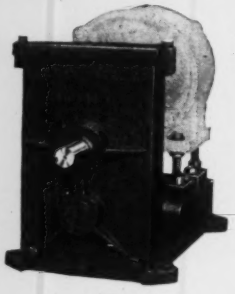

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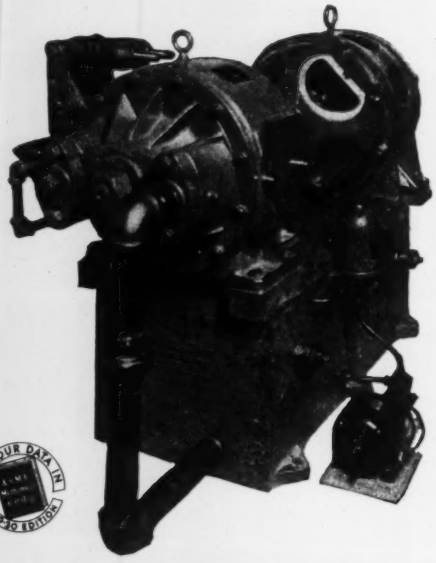

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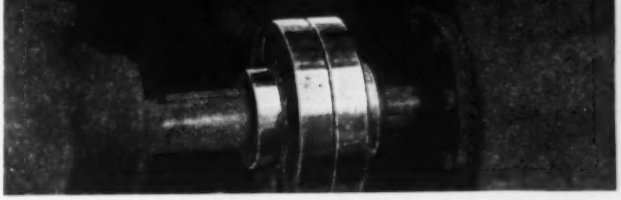

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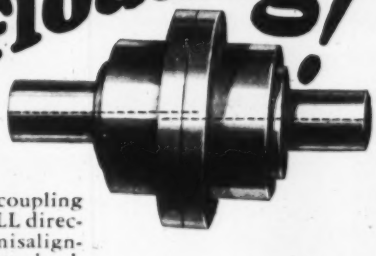

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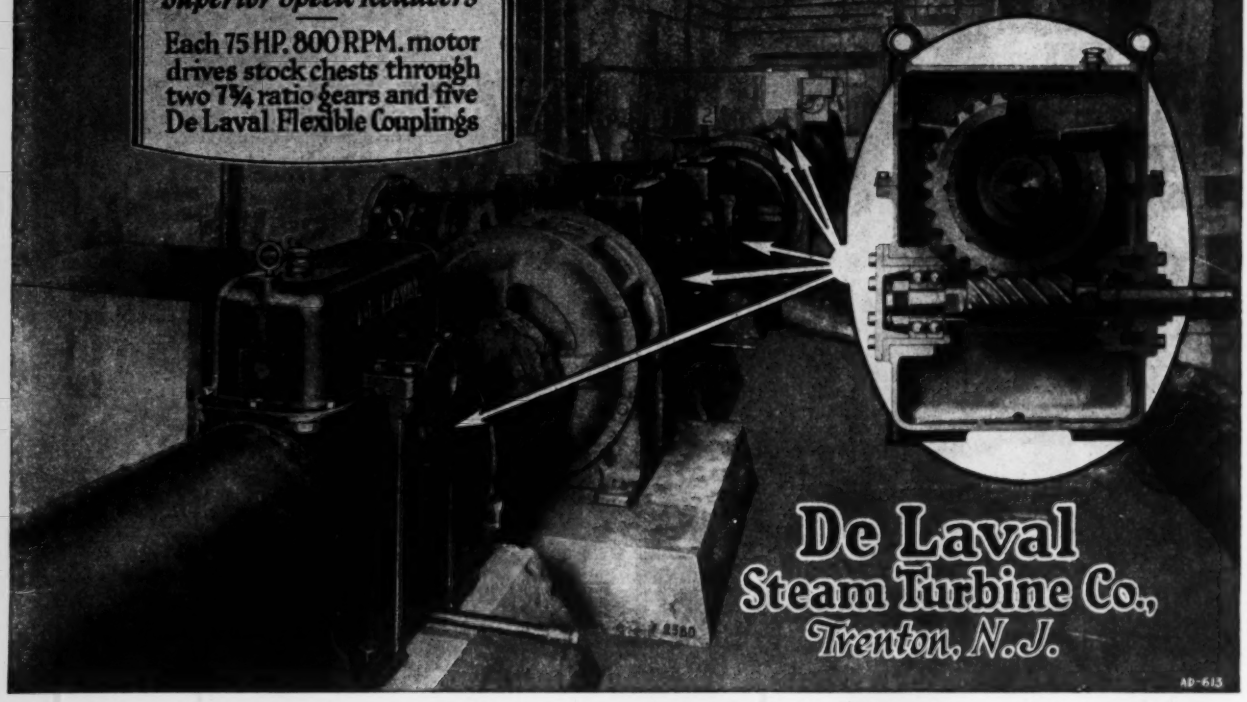

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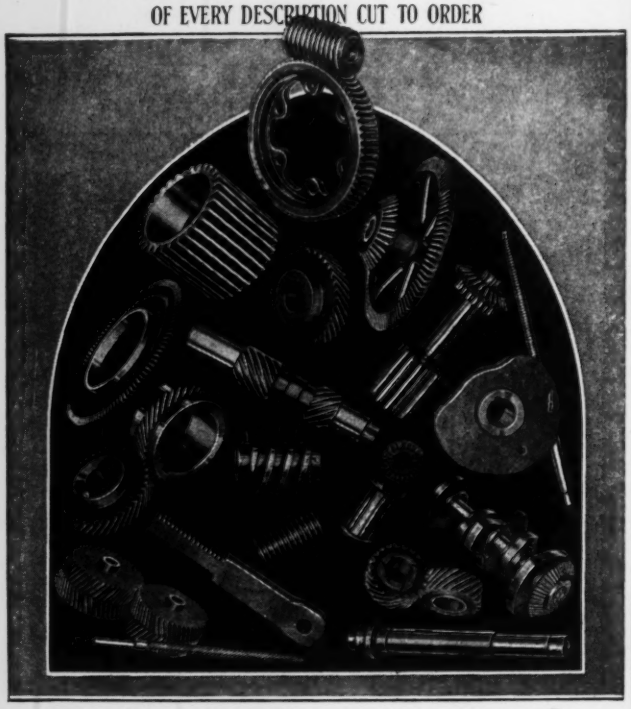

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Conditions so severe as to expose the faults of other drives, serve simply to emphasize the superiority of Diamond High-Speed Roller Chain. Leading plants standardize on it after test. Because of smooth, silent action, rolling at points of contact, simplicity and durability Diamond Chain reduces maintenance on the toughest drives—assures smoother production, lower power consumption, positive transmission. It delivers 98-99% of power—at any speed up to 3600 R.P.M.—on long or short centers. Facts you should know are in Booklet 102A. Send for it.

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DIAMOND CHAIN
ROLLING ~ AT POINTS OF CONTACT

Look for the Diamond on the Link

DIAMOND CHAIN & MFG. CO., INDIANAPOLIS, IND.

THE PRODUCT of 24 YEARS' EXPERIENCE

Palmer-Bee Herringbone Speed Reducers are backed by 24 years' experience in the power transmission field.

They embody every improvement and refinement known to engineering science.

Precision cut continuous tooth steel herringbone gears, mounted on alloy steel shafts, transmit the power silently, without vibration or appreciable wear.

Ball, Hyatt and Timken Bearings diminish friction to a minimum and help to produce an all-around efficiency of 98 to 99%.

Symmetrical arrangement of gears insures a balanced drive and uniform load on bearings.

Oversize shafts and bearings permit overhung loads up to maximum capacity of reducer.

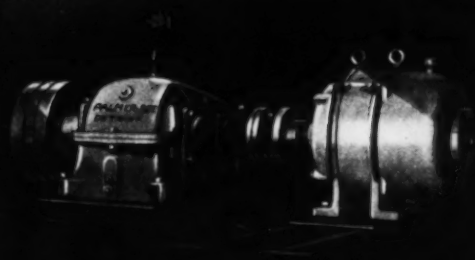
Nelson Patent Oil Seals prevent oil leakage.

A massive cast iron housing, tapered to insure utmost rigidity, keeps the gears in permanently accurate alignment.

A positive lubrication system minimizes wear.

Our Catalog No. 50 describes in detail the many exclusive construction features of Palmer-Bee Reducers. It contains tables of horsepower ratings and dimensions, as well as instructions regarding the selection of the proper size reducer, the correct method of installation and maintenance. Write for it.

PALMER-BEE COMPANY
Detroit, Mich.
1703-17 Poland Ave.



Established 1859

Between the covers you'll find--

Over 220 pages of engineering tables, data and formulae.

A total of 661 pages of invaluable data to engineers and power-plant superintendents and executives.

Information clearly set forth to answer your gear problems—your speed reduction problems, and general power transmission questions. Complete with prices and with descriptions of equipment.

Indexed and cross-indexed for you.

Used as a reference book by Engineering Departments of Industrial Leaders Everywhere.

IXL Products
SPEED REDUCERS
GEARS OF ALL KINDS
FLEXIBLE COUPLINGS
FRICTION CLUTCHES

POWER TRANSMISSION EQUIPMENT

Special Machinery Built to Order

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281-A

FOOTE BROS. GEAR & MACHINE CO.
Department 53
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Sales and Engineering Offices in All Principal Cities, U. S. A. and Canada

FOOTE BROS. GEAR & MACHINE CO.
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111 N. Curtis St
CHICAGO, ILL.
Send me a copy of "Gear Problems"

Signed _____

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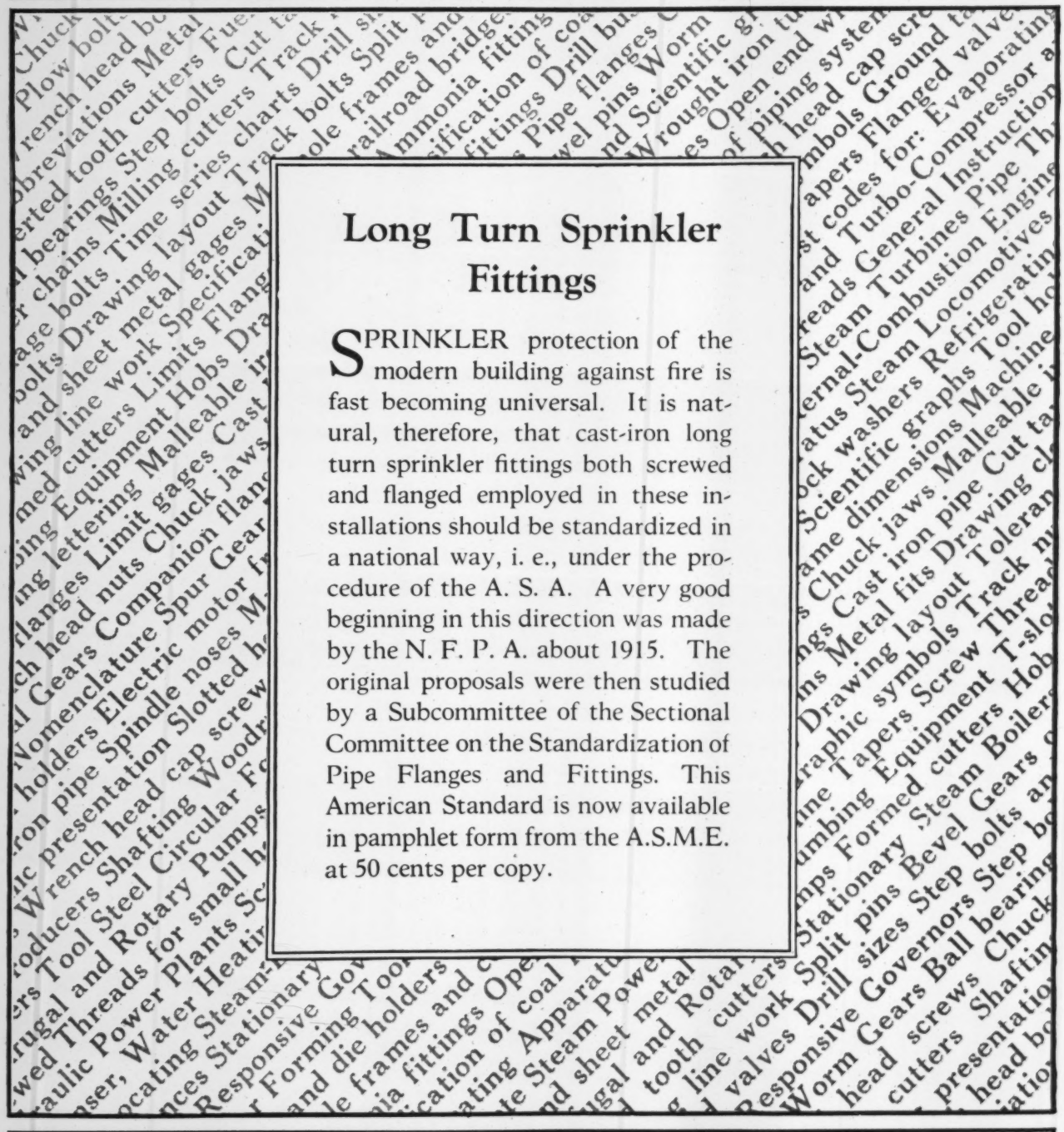
Engineering and Industrial STANDARDS



Long Turn Sprinkler Fittings

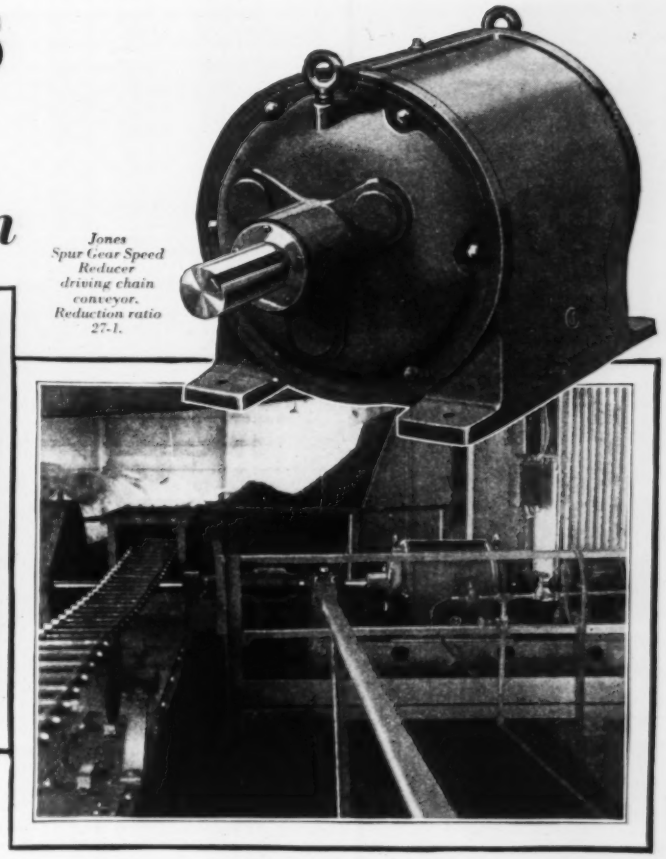
SPRINKLER protection of the modern building against fire is fast becoming universal. It is natural, therefore, that cast-iron long turn sprinkler fittings both screwed and flanged employed in these installations should be standardized in a national way, i. e., under the procedure of the A. S. A. A very good beginning in this direction was made by the N. F. P. A. about 1915. The original proposals were then studied by a Subcommittee of the Sectional Committee on the Standardization of Pipe Flanges and Fittings. This American Standard is now available in pamphlet form from the A.S.M.E. at 50 cents per copy.

The American Society of Mechanical Engineers

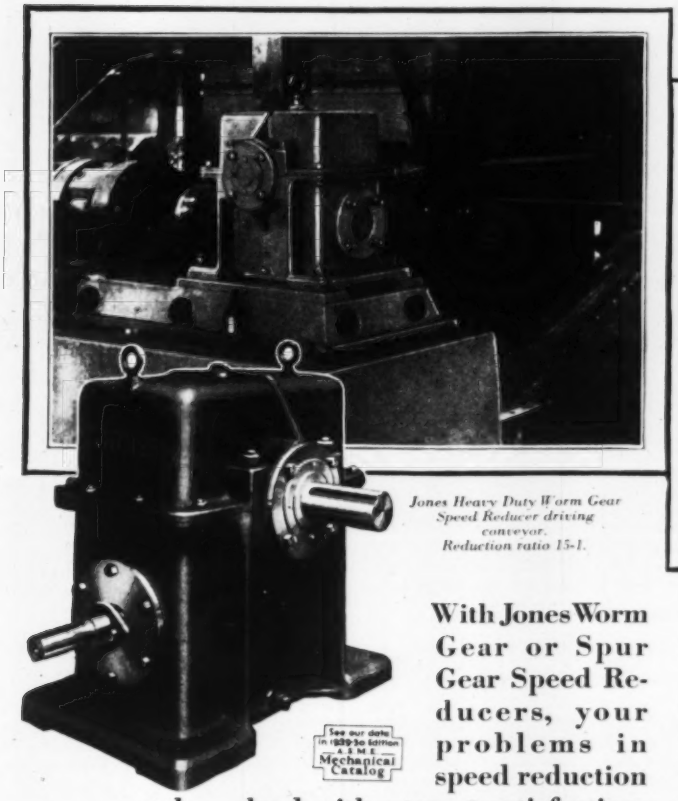
29 West 39th Street New York, N. Y.

TEAM MATES

...in Efficient Speed Reduction



Jones Spur Gear Speed Reducer driving chain conveyor. Reduction ratio 27-1.



Jones Heavy Duty Worm Gear Speed Reducer driving conveyor. Reduction ratio 15-1.

See our data in 1929-30 edition A. S. M. E. Mechanical Catalog

With Jones Worm Gear or Spur Gear Speed Reducers, your problems in speed reduction can be solved with utmost satisfaction.

The many economies effected by these reducers in lower installation and operating costs, combined with greater power transmission efficiency, enable them to quickly pay for themselves. They are self-contained, self-lubricated units requiring no attention other than occasional refilling of the oil bath.

Jones Spur Gear and Worm Gear Speed Reducers are correctly designed, simply and durably built of high quality materials. They will give you long, trouble-free service.

Jones Speed Reducers are made in a great variety of standard ratios, with parts in stock ready for immediate assembly and shipment. Write for catalogue.

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Main Office and Works: 4400 W. Roosevelt Road, Chicago, Ill.

Branch Sales and Engineering Offices:

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ST. LOUIS CINCINNATI KANSAS CITY, MO. LOS ANGELES SAN FRANCISCO

Jones Speed Reducers

Spur & Worm Gear

AETNA THRUST BALL BEARINGS

There is nothing romantic in the manufacture of a fine thrust bearing—to the man who buys it.

But to the Aetna organization, there is a story back of each bearing that leaves the factory—a story of skilled design and scientific manufacture.

Years of research and application to thrust bearing problems are responsible for Aetna superiority. Hence Aetna's world wide reputation as "Specialists to the Industry."

AETNA BALL BEARING MFG. CO.
4600 SCHUBERT AVE.
CHICAGO, ILLINOIS

Where, in industry, is ball bearing quality more cruelly tested?

AHLBERG BEARING COMPANY, 117-127 E. 29th St., Chicago, Ill.

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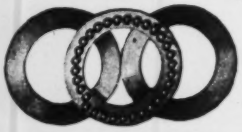
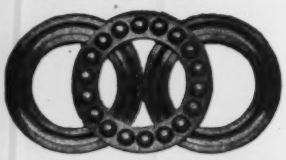
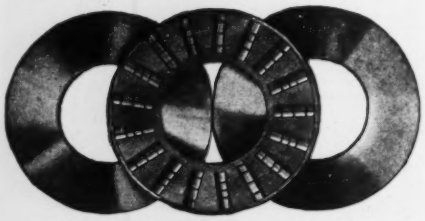
BALL AND ROLLER
BEARINGS
LIGHT DUTY—HEAVY DUTY



BALL THRUST BEARINGS
ROLLER THRUST BEARINGS
JOURNAL ROLLER BEARINGS
SPECIAL BEARINGS TO ORDER





STANDARD SIZES OR MADE TO ORDER
Any quantity—one bearing or one thousand

CATALOG UPON REQUEST

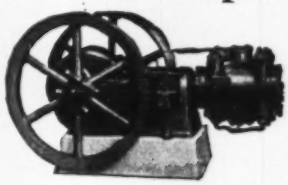
THE GWILLIAM COMPANY
360 Furman Street, BROOKLYN, N. Y.

See Our Data in 1929-30 A.S.M.E. Mechanical Catalog

Advertising Forms - of - MECHANICAL ENGINEERING close on the sixth of the month preceding date of issue.

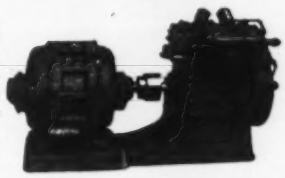
Space reservations, copy and cuts for advertisements to appear in the January issue should reach us not later than December sixth.

Two Popular Sullivan Compressors

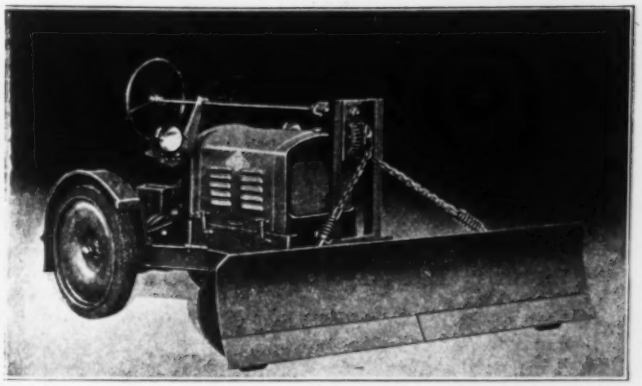


"WG-6" Belted Sullivan "WG-6" single stage compressors, capacities 68 to 6500 feet, are popular because they require so little attention. Splash lubrication, wafer valves, and sweep control unloading. *Catalog 83-I.*

"WL-" Direct Connected Sullivan two cylinder and four cylinder compressors, capacities 100 to 350 feet, combine direct connection with portability. Especially useful with automatic control. *Catalog 83-H.*



SULLIVAN MACHINERY COMPANY
702 Wrigley Bldg., Chicago



"Clarktor" Snow Plow (Code: "Snow") Length of blade 82 in. Width of Swath 74 in. Gas Powered. Standard "Clarktor" chassis.

"Clarktor" Snow Plow

A Tractor When the Sun Shines
A Life Saver When Snow Falls

When you need a snow plow you need it badly. This "Clarktor" Model doing general hauling duty becomes a snow plow in a few minutes whenever the emergency arises. Prevents interference with your work by the weather; clears a path six feet wide in the time it would take a gang of men with snow shovels to put on their coats. One man drives and controls the blade. Secure full details by clipping this ad and sending it with your name and address to

CLARK TRUCTRACTOR COMPANY
Battle Creek, Michigan

Pneumatic Conveying Systems

DESIGNED AND MADE TO EXACTLY MEET LOCAL CONDITIONS —
43 YEARS OF SUCCESSFUL EXPERIENCE
SEND FOR DATA

The Allington & Curtis Mfg. Co.
Saginaw Michigan

The Engineering Societies Library

One of the largest collections of engineering literature in the world is that found in the Engineering Societies Library, 29 West 39th Street, New York.

It comprises 150,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 1,700 technical journals and magazines are regularly received, including practically every important engineering journal published in the civil, mechanical, electrical, and mining fields.

The library is open from 9 a.m. to 10 p.m. with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

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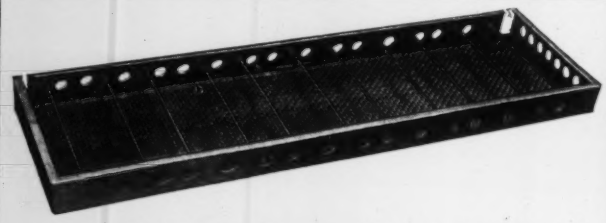
"BLUE CENTER" STEEL WIRE ROPE

A Superior Product Worthy of Your Consideration

John A. Roebling's Sons Co. Trenton, N. J.



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can be quickly accomplished and with little loss of production time

The cut illustrated here is a specially built drying tray (a very big order) where fast delivery was exacted from us, and we sustained our reputation for a good product delivered on time.

When you are confronted with a hurryup need for METAL PANS, TRAYS, BOXES or SPECIAL PARTS of SHEET METAL let us figure with you.

Pencil sketch or blue print needed.

THE BREESE BROS. CO.
Cincinnati, Ohio

MAKERS OF
TOTE BOXES—SHOP BOXES —PICKLING BASKETS

FABRICATORS OF
STEEL—IRON—BRASS—COPPER —MONEL METAL

Requiring
Stamping—Forming—Drawing
Blanking—Punching

See Data A.S.M.E. Mechanical Catalog, McRae Hendricks, Thomas Catalogues

FRANKLIN MACHINE COMPANY

Engineers Founders Machinists
Providence, R. I.

Iron Castings, George H. Corliss Engine, Harris-Corliss Engines, Brown Patented Valve Gear, Green-Wheelock Engines, Transmission Machinery, Spun Silk Machinery, French Worsted Drawing Frames (Frotteurs), Ball Winding Machines, Cotton & Silk Yarn Dressers, Power Shoe Lace Tipping Machines, Wool Top Baling Presses, Yarn Baling Presses, Pneumatic Gravity Drop Hammers, Pneumatic Presses, Paper and Pulp Mill Machinery, Worm Gears and Worm Gear Reduction Units.

TEXTILE PRINTING MACHINERY
MACHINERY FOR DYEING RAYON IN THE SKEIN

Save Cutting Oil the Economical Way

One 40-inch Tolhurst Chip Wringer will handle more work with much less labor than several small machines. In the 40″ and 48″ Tolhursts, long curly turnings are handled as readily as small chips.

TOLHURST MACHINE WORKS, INC.
Troy, N. Y.
New York Office: 30 Church St.
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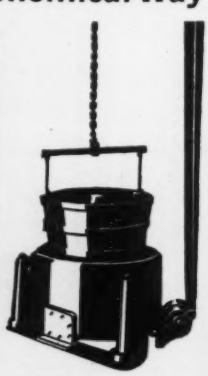
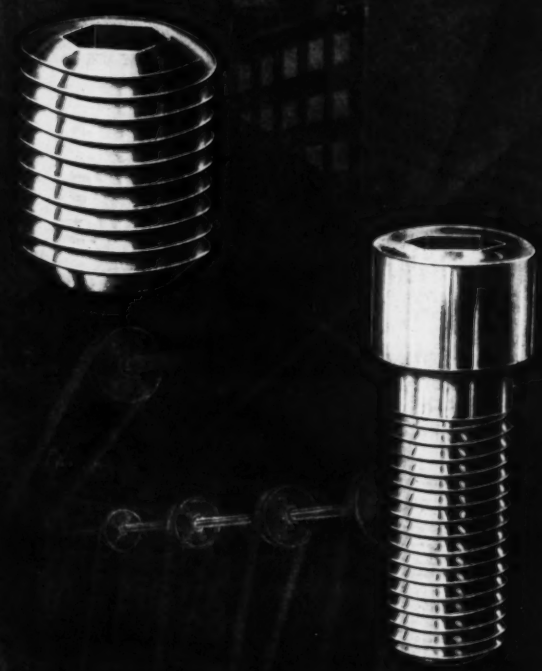


WRITE FOR CATALOG

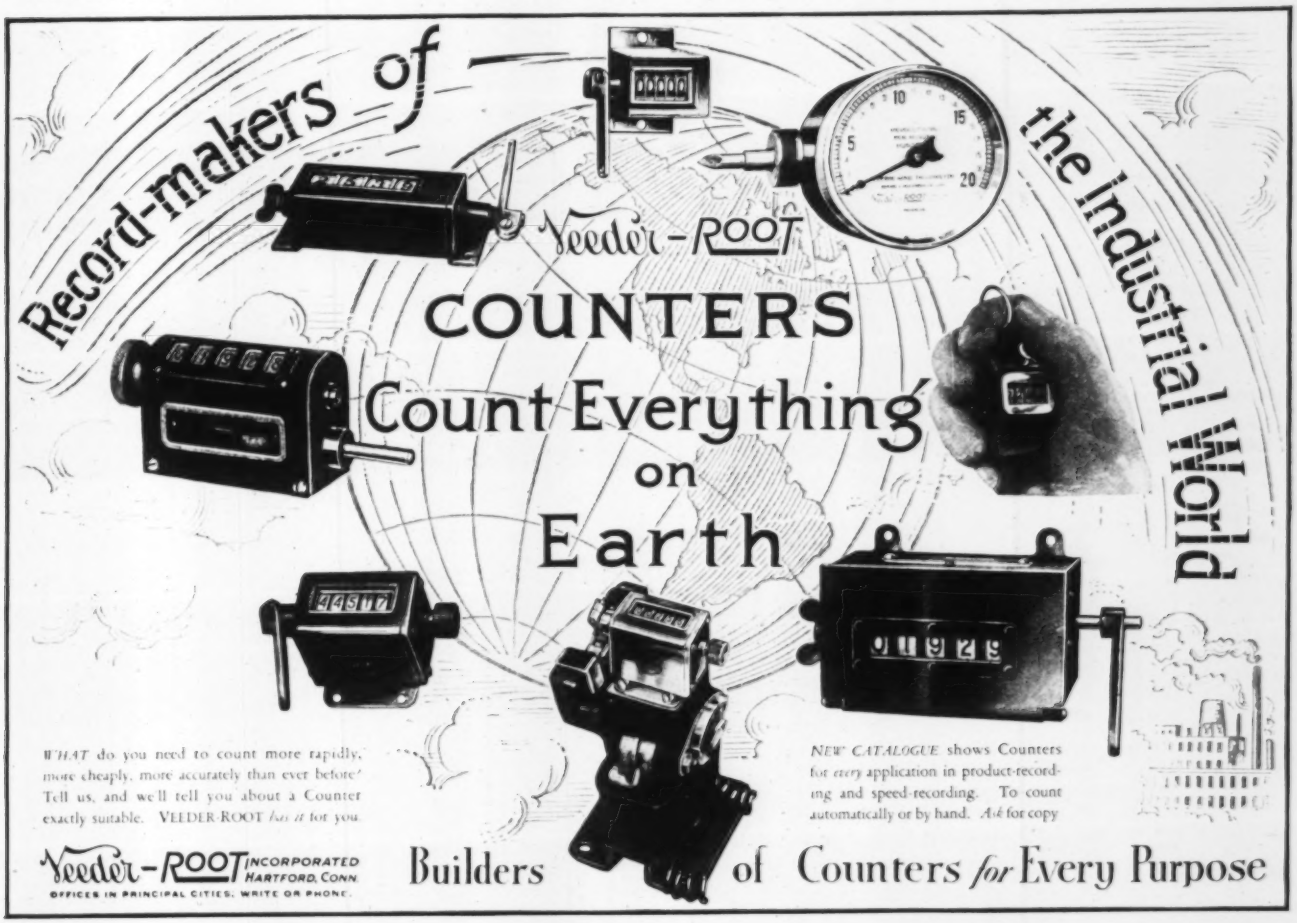
Allen Cold drawn



19 Years Make You SURE

You accept "ALLENS" like old friends; you use them with absolute confidence; you leave them with every assurance that they'll hold... After 19 years of careful development, you buy no experiment... Neither money, machinery nor ingenuity can give you a better screw—or ALLEN would give it to you.

The Allen Mfg. Company
Hartford, Conn.



J&L
JONES & LAMSON

Hartness Flat Turret Lathe
Fay Automatic Lathe
Hartness Automatic Die
Hartness Screw Thread Comparator
Flanders Ground Tap

JONES & LAMSON
MACHINE COMPANY
SPRINGFIELD
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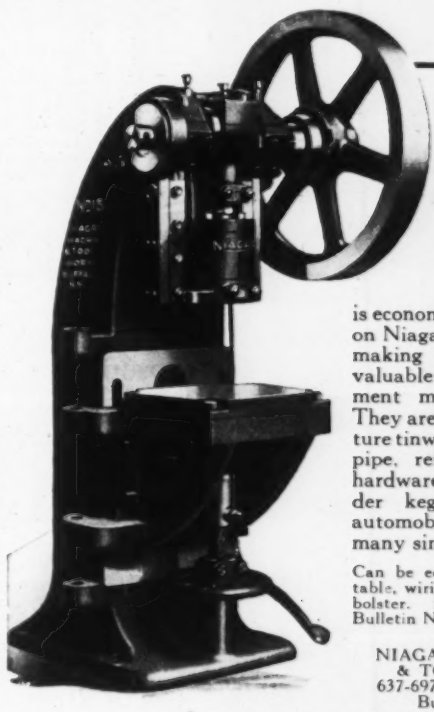

A Wide Range of Work

is economically performed on Niagara Horn Presses, making them especially valuable when press equipment must be limited. They are used to manufacture tinware, cans, furnace pipe, refrigerator boxes, hardware specialties, powder kegs, refrigerators, automobile wheels and many similar items.

Can be equipped with horn, table, wiring frame or sliding bolster. Fully described in Bulletin No. 60. Write for it.

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& TOOL WORKS
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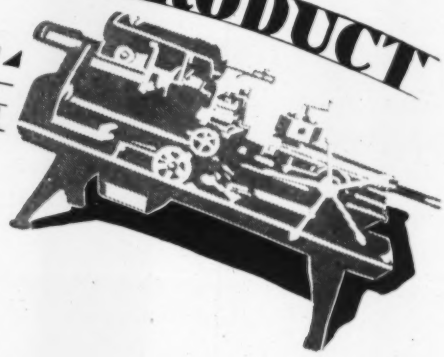
New York City 50 Church St. | Philadelphia Elverson Bldg. | Pittsburgh Park Bldg.

NIAGARA
PRESSES.....PUNCHES.....SQUARING SHEARS.....ROTARY SHEARS

THE EFFICIENCY of YOUR PRODUCT "Demands" the protection of BRISTO Safety SET SCREWS



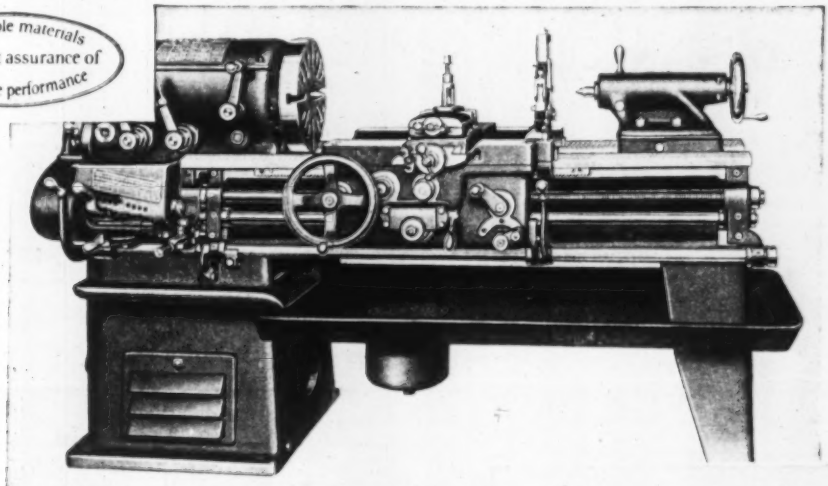
Typewriters and turret lathes, although widely separated in construction and operation, are linked in the common aim of making man's tasks a little easier. And so with every other mechanical product. ✪ ✪ ✪ In spite of this high purpose, however, your business existence as a manufacturer of any one of these products depends greatly upon the efficiency of that product in actual operation. You cannot even content yourself with building efficiency into it! You must guard that efficiency against misuse! You must make your product fool-proof. ✪ ✪ ✪ Because this is so, many manufacturers have turned to Bristo Safety Set Screws. ✪ ✪ ✪ The unique design of their patented, dove-tailed socket gives a perfect grip, and in addition discourages tampering, for it suggests that the screw is to be loosened or tightened *only with a special wrench.* (In reality it can be adjusted with a screw driver, or flat bar steel in an emergency.) ✪ ✪ ✪ Bristos can be set tighter and loosened more quickly than any other set screw. They are longer lived. Yet Bristo Safety Set Screws actually cost no more than ordinary socket set screws. ✪ ✪ ✪ May we send you samples? We would like you to prove their protection and efficiency to yourself.

BRISTO
SAFETY SET SCREWS

THE BRISTOL CO., WATERBURY, CONN.

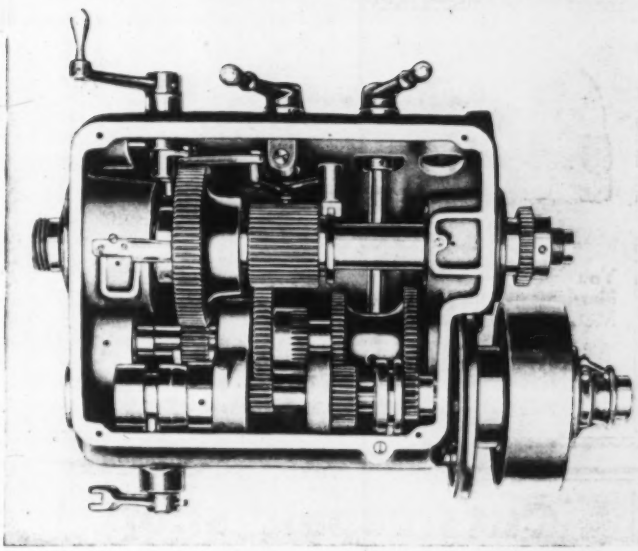
DEPT. AR

Dependable materials are the best assurance of dependable performance



Sliding gear head lathe mfd. by REED-PRENTICE CORPORATION, Worcester, Mass.

Headstock gear case open showing S. A. E. 3250 Nickel Chromium Steel gears used in Reed-Prentice lathes.



Nickel Alloy Steel assures dependable performance of gears in REED-PRENTICE Lathes

IN adopting S. A. E. 3250 Nickel Chromium Steel for gears used in the headstocks of their lathes, the Reed-Prentice Corporation have incorporated the same materials and manufacturing methods leading automobile manufacturers employ in producing quality transmissions.

The gears are heat treated in electric furnaces to insure uniformity of mechanical properties and when so treated possess high hardness with unusual toughness. In addition, since the use of Nickel Steels permits of lower heat treating temperatures, warpage and distortion are reduced to a minimum.

Probably the most impressive evidence of the uniformly dependable mechanical properties of Nickel Steels is the fact that practically all manufacturers of airplane engines, both in America and Europe, have adopted Nickel Alloy Steels for highly stressed parts, the weight of which must be pared to a minimum.

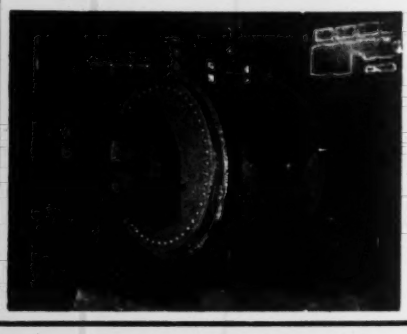
Nickel
FOR ALLOY STEEL

Information on the properties and applications of Nickel Alloy Steels will be gladly furnished by our staff of engineers. You are invited to write for additional data.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

DETROIT ELECTRIC FURNACES

THE STANDARDIZED MELTING MACHINES



FOR
BRASS
BRONZE
COPPER
ALUMINUM
GREY IRON

Detroit Electric Furnace Co.
825 W. Elizabeth St.
Detroit, Mich.

CANN & SAUL STEEL CO.

OPEN HEARTH & ALLOY STEEL **FORGINGS**

WELDLESS RINGS, GEAR BLANKS, SPINDLES & SHAFTS
SMOOTH FORGED OR ROUGH MACHINED

STAINLESS { IRON / STEEL
MONEL METAL
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NICKEL STEEL

FOR

VALVE SEAT RINGS
VALVE STEMS
PUMP RODS
PISTONS
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SPECIAL FACILITIES FOR **HEAT TREATING**

FORGED STEEL PIPE
ROUGH MACHINED — ALL TYPES STOCK SHIPMENTS

FLANGES
125-250 LB.
NEW STANDARDS
400, 600, 900, 1350 LB.

Plant
ROYERSFORD, PA.

Main Office
PHILADELPHIA

A Sample of Case-Hardening by the Gas Process

ARE YOU SATISFIED?

You will be—if you send your work to us—Case-Hardening — Hardening — Annealing — Tempering — Gun Metal Coloring, Etc.

AMERICAN METAL TREATMENT CO.
ELIZABETH, N. J.

See Our Data in 1929-30 A.S.M.E. Mechanical Catalog

DRY-SYS Equipment includes:

Finishing Room Equipment for all wood and metal products; Drying and Baking Ovens with trucks, racks, conveyors, washers, etc.; Foundry Core Ovens; Dry Rooms for high or low temperature; Air Conditioning Equipment; Industrial Furnaces; Heating Units for gas, oil or steam.

Descriptive literature on request.

DRYING SYSTEMS INC.
1812 Foster Ave., Chicago, Illinois

Cuts repair shop cleaning costs

HERE is a way to cut cost and effort on every cleaning job in your electric repair shop. Adopt safe Oakite cleaning materials and methods as standard and you will find that work is clean and ready for the repairmen in a fraction of the usual time.

Oakite cleaning removes grease, oil and dirt from motor frames, motor bearings, brush holders, etc.; strips varnish insulating compound from laminated cores of transformers; removes shellac from field and armature coils of generators and motors. And because Oakite action is so thorough, parts go through to repairmen quicker, cleaner, and easier to handle.

Write for "Oakite in Power Plants." It gives directions and formulas for doing every plant cleaning job economically and satisfactorily. A postal to us will bring you a copy. No obligation.

Oakite Service Men, cleaning specialists, are located in the leading industrial centers of the U. S. and Canada.

Manufactured only by
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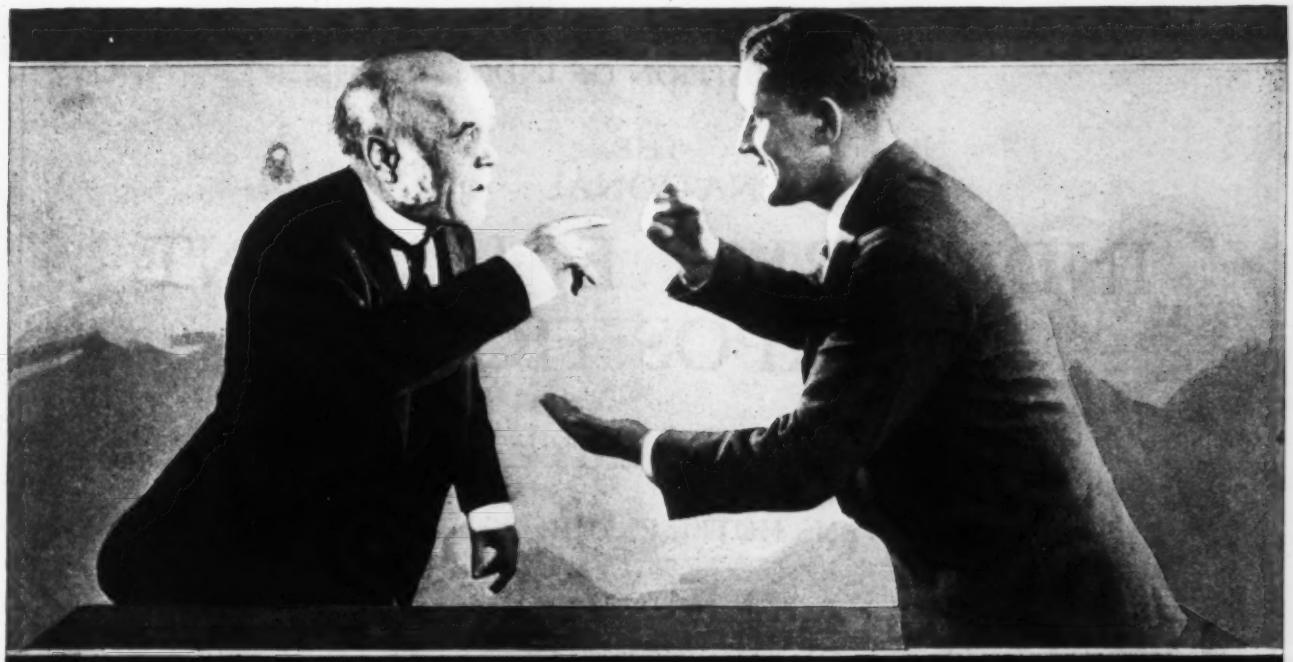
OAKITE
TRADE MARK REG. U. S. PAT. OFF.
Industrial Cleaning Materials and Methods

What better gift than good health?

BUY
CHRISTMAS SEALS

The National, State and Local Tuberculosis Associations of the United States



TRADITION PROGRESS

"Here, Lad—

You couldn't be so enthusiastic about 'Stable-Arc' welders if you didn't see something in them.

Just what DO you see?"

"Easy, Pop—

Sincerity is the first thing evident.

The arc welder is sold to a manufacturer who is expected to design his machinery for arc-welded production.

Now, the arc welder too is a piece of machinery.

If on the welder you see a welded frame generator driven by a welded frame motor, doesn't that inspire confidence in the sincerity of that welder maker's argument—viz: that you can build a thing better by arc welding.

The Lincoln 'Stable-Arc' welder is the answer since it's the most successful welder and is a *completely* arc-welded ensemble—motor, generator, frame, wheels and all.

It's a welded union—not a mixed marriage."

The Lincoln "Stable-Arc" Welder

— welds easier
— makes better welds
— permits greater output

because of the steady uniform arc throughout entire welding range, which is the result of:

Variable voltage design
Laminated magnetic circuit
Separately-excited generator field
Double control of welding heat
All steel construction

No other welder has all these features.

The Lincoln Electric Co.,
Dept. No. 24-12 Cleveland, O.

LINCOLN "Stable-Arc" WELDER

W-122

"THE EXPOSITION OF INDUSTRY"

THE
NATIONAL

INDUSTRIAL EQUIPMENT EXPOSITION

Chicago ... March 3-7; 1930

STEVENS HOTEL EXHIBITION HALL

INDUSTRIAL America during the past few years has undergone sufficient change to warrant attention to the problems of present Production and future trends of development. Progress has demanded a discarding of old ideas, ordinary, haphazard and makeshift plans for betterment, in favor of more business-like, scientific and accurate conceptions regarding the business future. No Industrial plant can be counted a factor in modern affairs unless it has modernized itself in ideas and equipment in conformity with the best present thought in its field of endeavor. Management, better working facilities, labor- and time-saving equipment, sanitary surroundings and cooperation are vital needs of the Industrial establishment carrying on to greater success.

Exhibits to Portray Industrial Progress

THE importance of the Industrial Establishment in American Industry and its influence on the lives of millions of workers will be fully emphasized in the diversified labor-, material-, and money-saving equipment which the National Industrial Show proposes to have on display. Manufacturers desiring to better serve Industry with Services, Materials, Equipment, Supplies and Appliances under the following classifications will find desirable contacts and extremely valuable prospects.

INDUSTRIAL PLANT CONSTRUCTION MATERIALS—Cements, Insulations, Paints, Windows, Doors, Roofing, Flooring, Elevators.

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Advance Announcement

NATIONAL MANAGEMENT CONGRESS

MARCH
3-4-5, 1930

STEVENS HOTEL
Chicago

MEETINGS covering six sessions will be held at the Stevens Hotel, running concurrently with the Industrial Equipment Exposition. Co-operating Societies—American Society of Mechanical Engineers; American Management Association; Society of Industrial Engineers; National Association of Cost Accountants.

The Congress will feature papers by leading Industrialists on modern methods and latest practice in the field of Factory Management and Operation. Of great interest to Factory Executives, Superintendents, Production, Maintenance and Plant Engineers, will be the open Forum for general discussion of industrial plant problems.

Subjects to be included for presentation and discussion, among others, will be the following:

"Plant maintenance as a factor in greater Production."
"The possibilities of greater mechanization in industry."
"The part of Management in future industrial production."
"Development of Production control systems."
"Symposium on Reclamation and Utilization of waste."
"Time study and wage incentives."
"Safety and its effect on better Production."

Besides the above mentioned sessions, there will be important inspection trips to leading industrial plants where latest practice and most modern ideas in management, maintenance, production and operation can be seen and studied.

THIRD NATIONAL MATERIALS HANDLING MEETING

of The
American Society of
Mechanical Engineers

MARCH
5-6-7, 1930

STEVENS HOTEL
Chicago

THE THIRD NATIONAL MEETING on Materials Handling will be held at the Stevens Hotel, running concurrently with the National Industrial Equipment Exposition. There will be three main sessions, several informal gatherings and three mornings devoted to inspection of materials handling equipment in actual operation. The technical program will contain papers of wide general and specific interest in the field of mechanical conveying, packaging and materials handling.

As this meeting will be the greatest ever proposed in dealing with the important subject of materials handling, a real opportunity will be available to meet the country's leading experts. Users of equipment will find this a meeting of common interest for the intimate exchange of information.

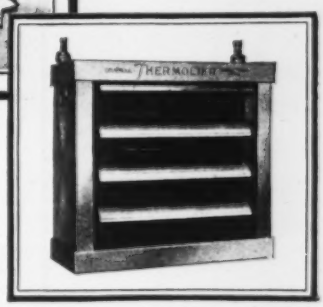
Subjects of papers will include:

"Essential requisites to successful materials handling installations."
"Labor and time saving possibilities in mechanical conveying."
"Layout of individual systems for efficient material handling."
"Maintenance of materials handling equipment and its importance."
"Coordination of equipment for successful, low-cost handling of materials."
"Modern package handling and shipping."
"Automatic and electric features in Handling Equipment."
"Materials Handling safety precautions."

One of the machine shops of a prominent New England manufacturer showing one of the 55 Thermolier copper unit heaters.

Thermolier
the copper unit heater

Made in eight models to fit any space and every condition.



Constant, uniform *heat as evenly distributed as sunlight*

YOU ask "But where's the heating equipment?" when you visit this extensive, long-established New England manufacturing plant, a corner of which is reproduced above.

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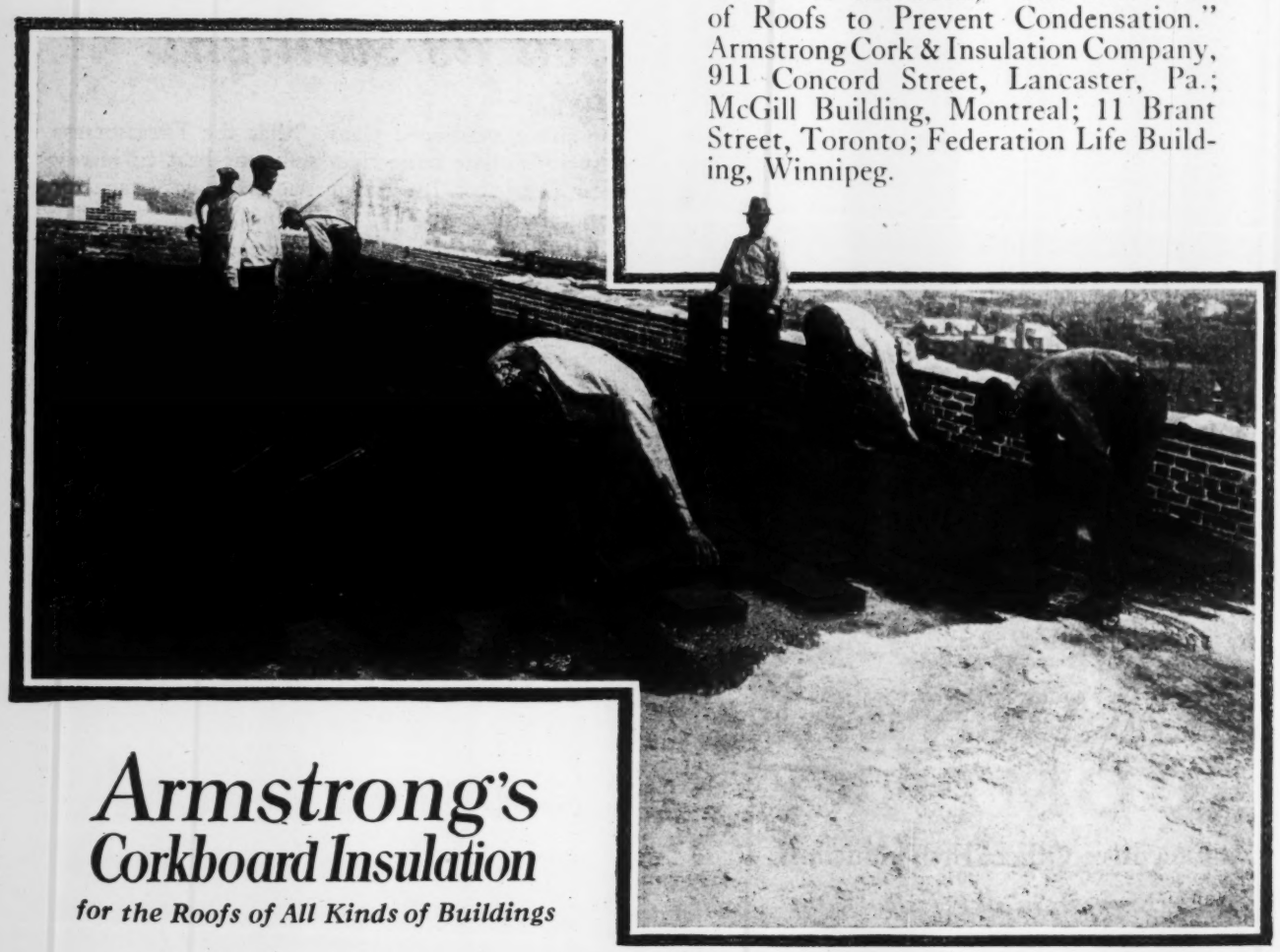

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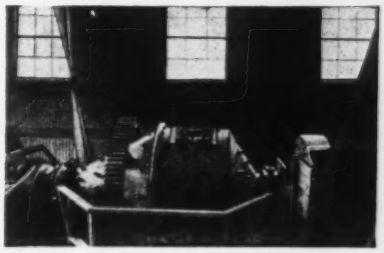

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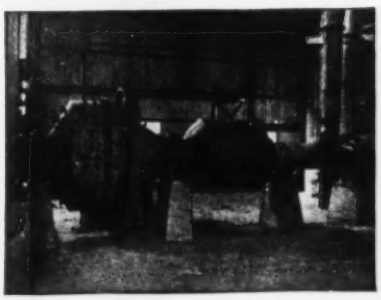
Cement Clinker

A few Hardinge Mill Installations

Fire Brick



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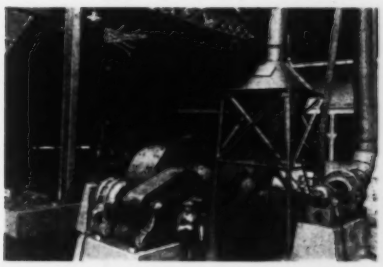

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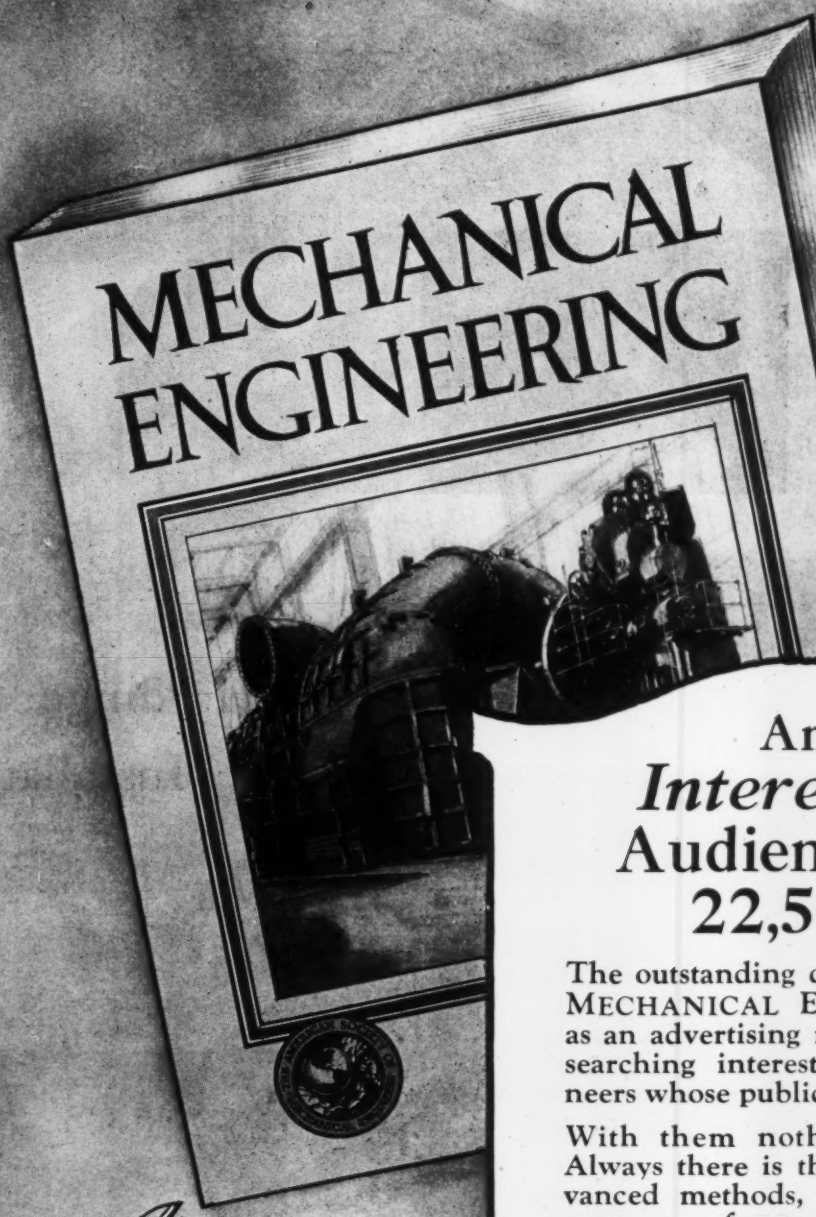

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Land Title Bldg., Philadelphia, Pa.

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MECHANICAL ENGINEER, Italian college graduate, going to Brazil, would like to hear from American manufacturers who would be interested in having a sales representative in that country. Address EX-774, care of this journal.

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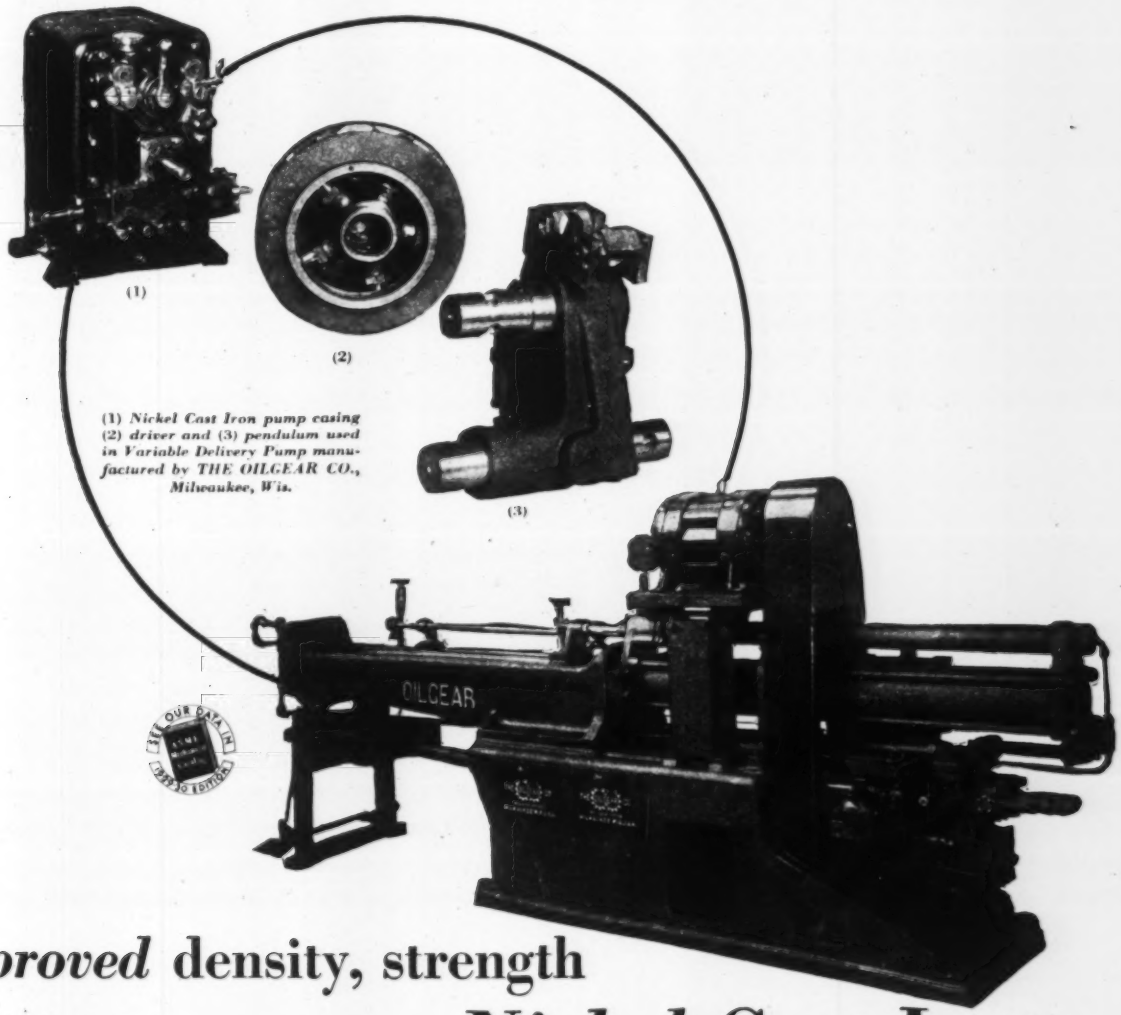

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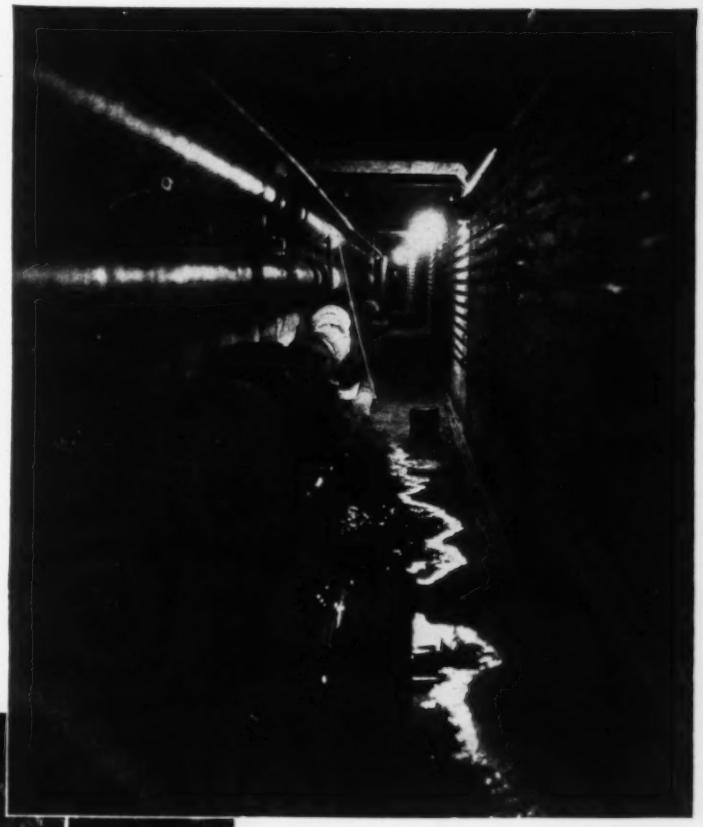
Heat Insulation is a "major" at this University!



A view of the underground steam piping at Purdue. Much of which is heat-insulated with Carey 85% Magnesia—efficiently protected against the cold and dampness of the tunnel.

The campus of Purdue University, La-Fayette, Indiana, where thirty-two buildings are heated from a single central plant.

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More than nine thousand feet of piping, up to sixteen inches in size, *wears an overcoat of Carey 85% Magnesia*. Almost two miles of it, the economical super-protection for high temperature lines!

If you have a heating or insulating problem of any kind, you will spend a few hours to good advantage with Carey engineers. The services of the Carey staff are at your disposal, any time.

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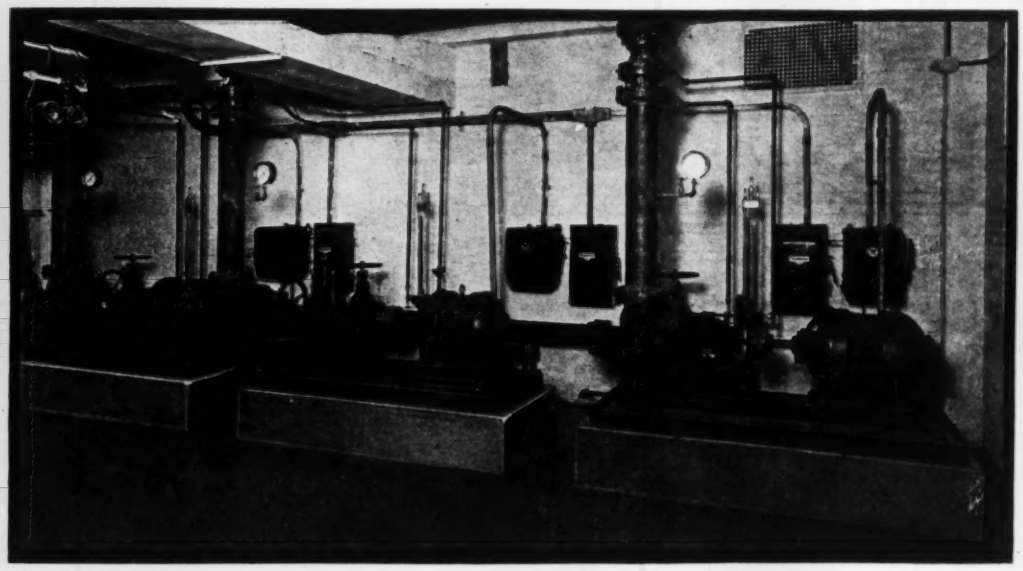
Carey HEAT INSULATIONS

For every need . . . from residence to super power plant



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installed in

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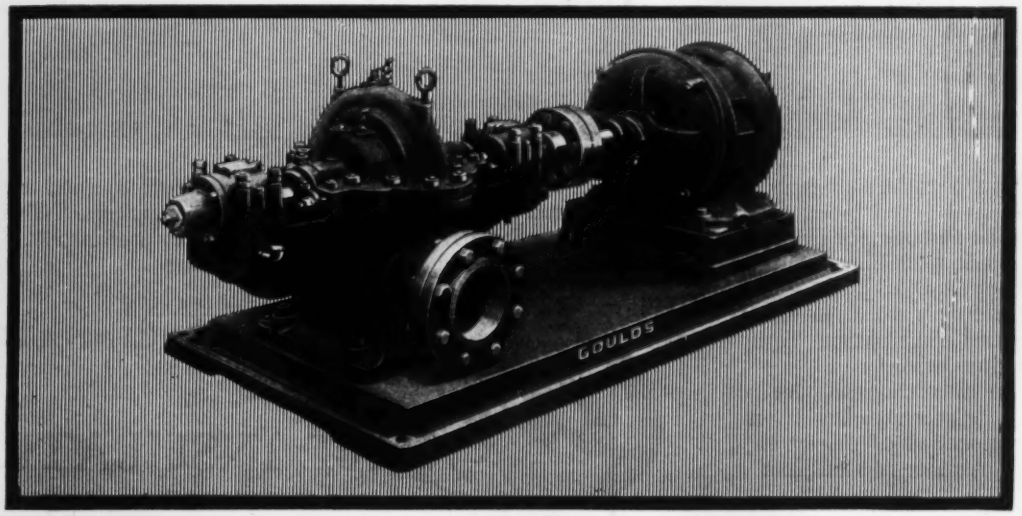
Located on the Boardwalk, with the Atlantic Ocean for its front yard, the new mammoth Atlantic City Convention Hall is commanding unusual interest from architects and engineers everywhere.

The structure was built at a cost of fifteen million dollars and is operated by the municipal government with the aid of a citizens' committee. Covering an entire city block and measuring 350 feet wide by 650 feet deep, it houses within its walls the world's largest auditorium, an enormous ballroom, two completely equipped theatrical stages, two bath houses and equipment for making an artificial ice skating rink.

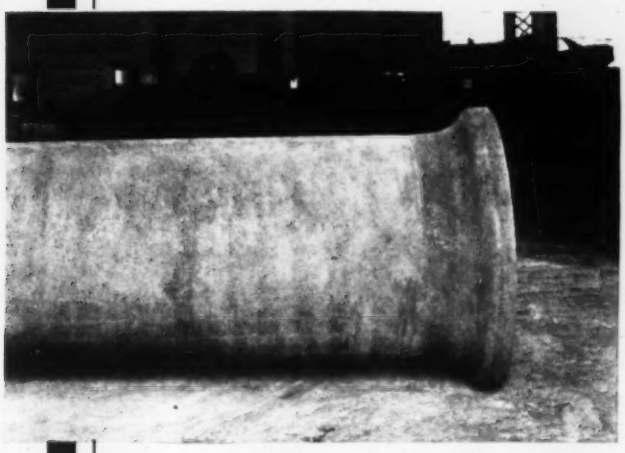
This skating rink equipment includes the three GOULDS Centrifugal Brine Circulating Pumps shown above. Modern buildings of this type demand modern pumping equipment. And so GOULDS was chosen. For absolute dependability, high maintained efficiency, and trouble free operation, specify GOULDS.

A representative of Goulds Pumps is near you.
He will be glad to serve you at any time.

GOULDS PUMPS, INC.
Seneca Falls, New York



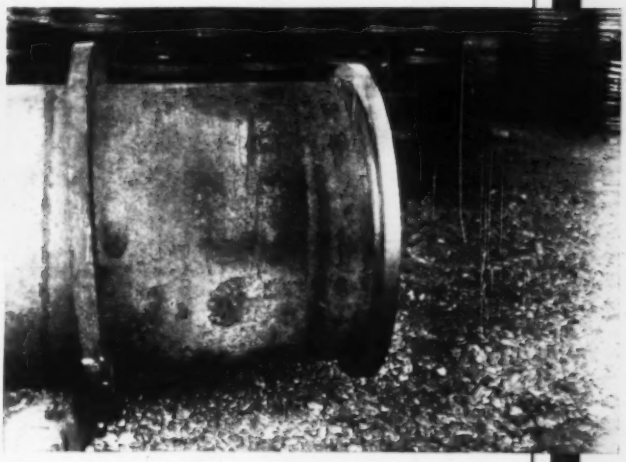
Large diameter pipe for difficult conditions



36" to 46" expanded end ½" thick

36" to 30" swedged end ⅝" thick

36" pipe end Van Stoned 47" O.D.



28" square corner upset forged end

FORGE Welded with ends formed integral with the pipe, Taylor Forge Welded Pipe meets difficult piping conditions. Our special equipment enables us to provide the most difficult connections.

Made in sizes 16" to 96" diameter and in lengths up to 100 feet—covers a wide range of uses, some of which are listed here.

High Pressure Penstocks
Drier Shells
Intake Piping
Reheat Piping
Low Pressure Steam Piping
Pressure Vessels
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Submit your pipe or shell problem to our Engineering Department

TAYLOR FORGE & PIPE WORKS

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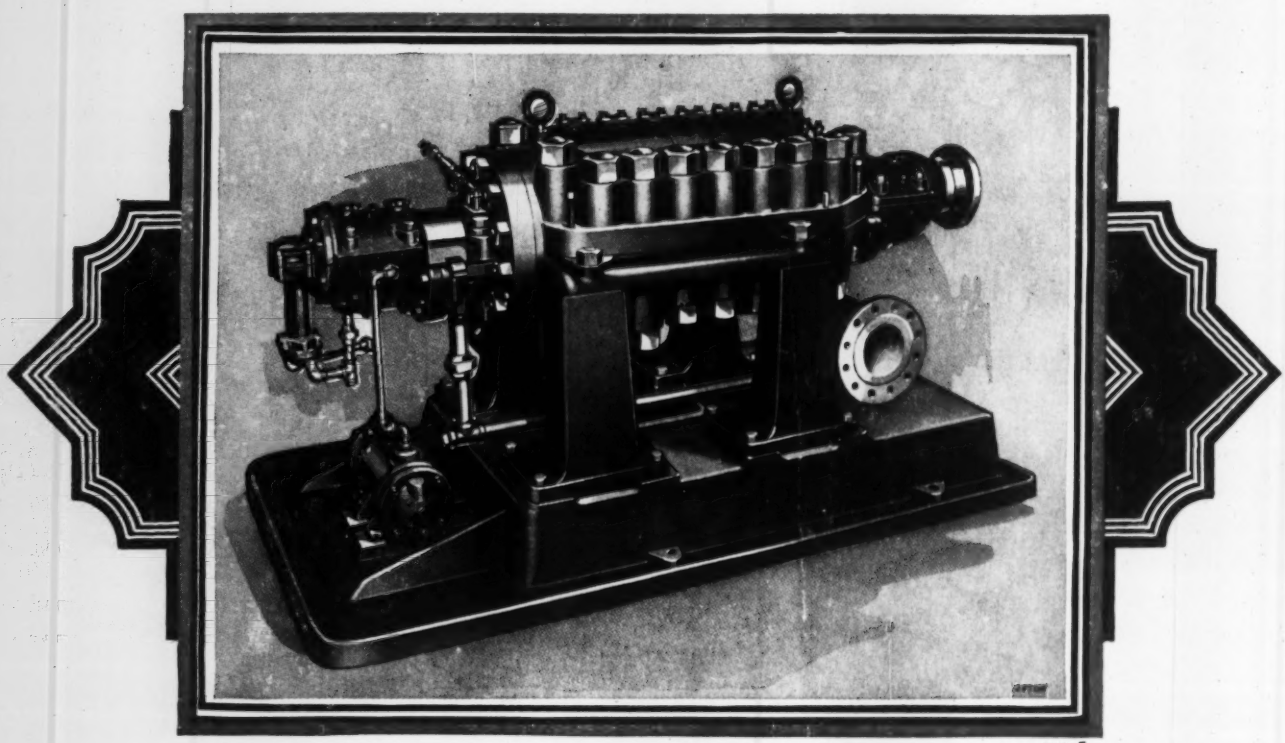
ME12-Gray



Cameron Boiler Feed Pumps—

Because its energies have been dedicated to progress, Cameron has always been the pacemaker in the field of pump manufacture.

Fifteen years ago, Cameron Centrifugal Boiler Feed Pumps were built for pressures up to 300 lbs. and were considered the pioneers and leaders in this class of equipment.

Today, Cameron Boiler Feed Pumps are built for pressures up to 2,000 lbs. and for capacities ranging from 125 to 3,000 gals. per minute. They set a new standard for this type of service and Cameron is still the pioneer—is still the leader.

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